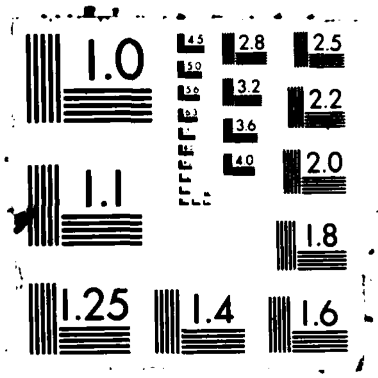
AD-A182 599 ANALYSIS SYSTEMS FOR AIR FORCE MISSIONS(U) BOSTON COLL 1/2
CHESTNUT HILL MA SPACE DATA ANALYSIS LAB
D E DELOREY ET AL 28 FEB 87 BC-SDAL-87-1
UNCLASSIFIED AFGL-TR-87-0100 F19628-83-C-0100 F/G 14/2 NL


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
6.3

(12)

AFGL-TR-87-0100

ANALYSIS SYSTEMS FOR AIR FORCE MISSIONS

Dennis E. Delorey
Brian F. Sullivan
Paul N. Pruneau

Space Data Analysis Laboratory
Boston College
Chestnut Hill, MA 02167

February 28, 1987

Final Report
4 June 1983-31 January 1987

Approved for Public Release, Distribution Unlimited

Air Force Geophysics Laboratory
Air Force Systems Command
United States Air Force
Hanscom AFB, Massachusetts 01731

87

"This technical report has been reviewed and is approved for publication"

(Signature)
ROBERT McINERNEY
Contract Manager

(Signature)
ROBERT McINERNEY
Branch Chief

FOR THE COMMANDER

(Signature)
ROBERT McINERNEY
Acting Division Director

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION: UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT: Approved for public release; distribution unlimited
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S): BC-SDAL-87-1	5. MONITORING ORGANIZATION REPORT NUMBER(S): AFGL-TR-87-0100
6a. NAME OF PERFORMING ORGANIZATION: Space Data Analysis Laboratory; 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION: Air Force Geophysics Laboratory
6c. ADDRESS (City, State and ZIP Code): Boston College, Chestnut Hill, MA 02167	7b. ADDRESS (City, State and ZIP Code): Hanscom Air Force Base, Bedford, MA 01731
8a. NAME OF FUNDING/SPONSORING ORGANIZATION: Air Force Geophysics Laboratory; 8b. OFFICE SYMBOL (If applicable): LCY	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER: F19628-83-C-0100
8c. ADDRESS (City, State and ZIP Code): Hanscom AFB, MA 01731-5000; Monitor: Robert E. McInerney	10. SOURCE OF FUNDING NOS.

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT NO.
61102F	9993	XX	YJ

11. TITLE (Include Security Classification): Analysis Systems for Air Force Missions

12. PERSONAL AUTHOR(S): Dennis E. Delorey, Brian F. Sullivan, Paul N. Pruneau

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Yr., Mo., Day)	15. PAGE COUNT
Final	FROM 6/4/83 TO 1/31/87	87 / 02 / 28	104

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB. GR.	Scientific Data Analysis Systems (SDAS); Experimental Data Bases; Attitude development

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Data analysis systems have been designed, developed, and implemented for various Air Force missions. Data bases for on-board experiments such as photometers, spectrometers, accelerometers, particle detectors, and magnetometers have been created.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT: UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS ☐	21. ABSTRACT SECURITY CLASSIFICATION: Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL: Robert E. McInerney	22b. TELEPHONE NUMBER (Include Area Code): (617) 337-3718; 22c. OFFICE SYMBOL: AFGL/LCY

DD FORM 1473, 83 APR — EDITION OF 1 JAN 73 IS OBSOLETE.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

TABLE OF CONTENTS

1.0 Overview

The Space Data Analysis Laboratory (SDAL) of Boston College was contracted by the Air Force Geophysics Laboratory (AFGL) Aerospace Engineering Division (Data Systems Branch) to perform multiple tasks related to spacecraft missions. These tasks included the developing of data bases for a multitude of scientific instruments; developing and implementing analyses using the data bases as the prime input; and providing significant input to Data Management Plans for several missions.

The contract number under which these efforts were performed was F19628-83-C0100.

Data systems were designed for several satellite projects. Satellites involved in these efforts include HILAT, Polar Bear, and S85-1. Systems were also designed, developed and implemented for flights of the Space Transportation System. In addition, analytic systems were setup for several rocket projects.

System design used modular programming techniques to provide the necessary flexibility in satisfying requirements in a cost effective manner. Subroutine libraries were developed for use in the overall systems. These libraries allow for the performance of common tasks and assure that these tasks are executed in identical manners.

2.0 HILAT Analyses

The HILAT spacecraft designated P83-1 was launched into polar orbit on a Scout rocket on 27 June 1983 from Vandenburg AFB. The HILAT payload was designed to provide data for the study of plasma density irregularity dynamics in the high latitude ionosphere. The spacecraft orbit is near circular at 800km with an orbital period of approximately 101 minutes. In addition, the vehicle is near three axis stabilized (drifts in pitch, yaw and roll can be seen on each acquisition).

HILAT operates in real time mode only with data transmitted to any of four ground stations. Three of these stations are at fixed high latitude sites (Tromso, Norway; Sondrestrom, Sweden; and Fort Churchill, Canada). The remaining station, refered to as the Rover, is moveable from location to location although it's most frequent site is Seattle, Washington.

The HILAT payload consists of a coherent beacon which provides scintillation and total electron content data; a Thermal Plasma Monitor which consists of an Electron Sensor, Retarding Potential Analyzer (RPA), and Ion Driftmeter (IDM); an Electron Spectrometer for the measurement of electron flux in the energy range between 20 eV and 20 keV; the Auroral Ionospheric Mapper (AIM) which consists of a scanning imager (which failed on 23 July 1983) and two photometers; and a triaxial fluxgate magnetometer. Attitude data is computed using the triaxial magnetometer along with a sun sensor.

For each station pass, the downlinked data is digitized by the station computer onto a disk file of the raw telemetry data. Between station passes, the raw data is semi-processed and put onto a disk file in "Summary Tape" form. As time permits, the raw data files are off-loaded onto "Raw Tapes" and the "Summary files" off-loaded onto tapes refered to as Summary Tapes.

Data on the raw tapes consists of station coordinates, Keplerian elements, spacecraft position, time tagged raw telemetry data in packed form, and raw scintillation data. Raw tapes from Tromso are received at AFGL where they are logged and archived.

The Summary Tape structure has evolved into a form of interlaced records which contain time, geometry and model magnetic field data; raw telemetry data; scintillation summary data; and science summary data. Each file contains data from one station pass. Summary tapes from all stations are received at AFGL where they are quality checked, copied for dissemination to other user agencies and used as the basic input to the Scientific Satellite Data Analysis System (SSDAS) efforts. SDAL personnel were deeply involved in the design of and parameter selection for the Summary tapes.

Under this contract SDAL personnel were responsible for the design, development and implementaion of the SSDAS for HILAT. This system, as with SSDAS design for other vehicles, was built in modular form to minimize effort duplication where commonality of requirements exist; to insure that common efforts are performed in exactly the same way in all routines; and to provide the flexibility necessary as spacecraft anomalies occur or requirements change. A library of HILAT routines has been developed which is used by all processing routines as necessary.

Upon receipt of a shipment of Summary tapes, the quality check (Q/C) and tape copy effort must be immediately initiated since the tape copies are to be shipped to the appropriate outside agencies for performance of their own analyses. The Q/C-Copy routine was designed to also produce a Summary Tape log which includes tape number and start and stop times of all passes on each tape. One such tape log is created for data from each station.

Since the tapes are written on a Hewlett Packard computer with various combinations of 16 and 32 bit fixed and floating point words, the initial SSDAS effort consists of reformatting the summary tapes for use on the central site computer. Upon completion of the reformatting effort, the original Summary Tapes are archived.

The AFGL payloads on HILAT consist of the AIM, Electron Spectrometer and Thermal Plasma Monitor. Data bases for these instruments along with the magnetometer and scintillation data are created in time history form. These data bases are then used as input to modular routines which produce microfiche displays of computed parameters. For the AIM, Electron Spectrometer, Thermal Plasma Experiment and Magnetometer two types of displays are produced; summary and detailed data. The summary displays consist of averaged data for entire passes. Thus, these plots provide a survey of the instrument data on a pass by pass basis. The detailed displays contain all point data plotted on a sequence of time overlapped frames for each pass. These displays are useful for event studies. The displays for each of the instruments are on common time scales to allow for correlation.

For the Thermal Plasma Experiment, individual modules were developed for each of the three independent experiments. For these, data is readout of telemetry in 64 second blocks which can be further subdivided into 8 second segments. The initial effort consists of identifying the beginning of an 8 second block and determining the subsection number within the 64 second cycle. Once found, the data must be accumulated in 64 second groups. These 64 second sections contain all readouts for the Electron Sensor, RPA and IDM.

The Electron Sensor is used to obtain electron density and frequency data. For the swept portion of the cycle, the beginning of each sweep must be determined. Once found the telemetry values are converted to sweep voltage. The sensor output, which is readout 4 times more frequently than the sweep voltage, is converted to telemetry voltage and then to current. The sensor potential must be calculated from the subcommutated data. A modular routine developed for electron density determination then receives as input the array of ordered pairs of sweep voltage and current along with sensor potential and returns electron density, electron temperature, and vehicle potential with respect to the plasma. Electron frequency data is also obtained at 4 fixed frequency values. The frequency determinations must first be made. The root-mean-square (RMS) values for each of the frequencies are then computed.

The RPA data consists of 2 and 4 second sweeps. The beginning of each 2 and 4 second sweep must first be determined. Once determined, the sweep voltage values are converted to actual sweep voltage and the sensor output converted to current. A modular routine then receives as input the ordered pairs of voltage and current along with total spacecraft velocity and sensor potential. The routine then computes and returns the ion temperature and drift velocity of ions normal to the RPA aperture.

The IDM cycle is 8 seconds. The horizontal and vertical telemetry values must first be identified and converted to horizontal and vertical drift tangents. A combination of 8, 9 and 10 bit words must be deconvolved from exponent and mantissa telemetry in order to obtain offset and re-zero values which are used in the calculation of tangent values. From the tangent data another modular routine is used which applies formulae to compute ion density and drift velocities.

A data base of TPE parameters along with selected ephemeris and magnetic parameters is created.

The Electron Spectrometer, refered to as the J-Sensor, has three modes of operation. Three sensors are mounted at zenith, 40 degrees from zenith, and nadir. Mode 1 consists of zenith data with 8 points per spectra; mode 2 also consists of zenith data with 16 points per spectra; in mode 3 data from all three detectors is acquired. Bit flags identify 'even' and 'odd' blocks. Initially, even blocks must be identified in order to determine the instrument mode. Once identified, data must be accumulated into 1 second blocks since this is the instrument cycle. The J-Sensor data base consists of structured records which identify instrument mode, the deconvolved instrument counts arranged from lowest to highest energy, decompressed magnetometer counts, and the required ephemeris parameters. This data base has been stored in counts because of the fact that for particle detectors, calibrations are likely to change as a function of time from launch and had calibrations been directly applied yet changed, data base recreation would have been necessary. A modular routine exists which has the calibration parameters stored as a function of time from launch. This routine is applied whenever differential flux or distribution function computations are required. For instance, in the summary plot display routine total flux, total energy flux and total energy are computed by integrating the spectra. This display routine utilizes the calibration subroutine. The deconvolved magnetometer counts were included in the J-Sensor data base because magnetic pitch angle is often required in the interpretation of differential flux data. Again, the magnetometer data was retained in counts to allow for modified calibrations. A simple change to the calibration module has taken care of upgrades to the magnetometer and J-sensor calibrations.

For the AIM sensors, individual modules were developed to handle the various sensor modes (i.e. imaging, spectrometer and photometer). This proved to be a most useful design concept since the imaging mode failed approximately one month after launch. The AIM data base has been succesfully created for all operational passes. Upon notification that the imager had failed, the "CALLS" to the imager subroutine were simply deleted from the AIM routine as opposed to rewriting the routine to accomodate the failure.

The photometer portion of the routine remains intact as originally designed and the photometer data base continues to be created. This data base consists of the photometer counts along with required ephemeris and attitude parameters. A calibration subroutine is used whenever calibrated photometer data in Rayleighs is required.

The scintillation data base continues to be created from parameters contained on the time/geometry/magnetic field records along with the scintillation records from the summary tape. A by-product of this data base is the scintillation statistics data base. This data base is created by inputting the overall scintillation data base and extracting segments based on quantized time periods and averaging the parameters on ephemeris constraints. Analysis techniques and computer routines have been developed to input the statistics data base and perform the necessary statistical analyses.

The appendix contains a sample of the HILAT tape log, the Summary Tape format and the data base formats for the various experiments.

3.0 Polar Bear Analyses

The Polar Bear satellite was launched on a Scout rocket in the fourth quarter of 1986. The spacecraft is very similar in design to HILAT. It was launched from Vandenburg AFB with an inclination of nearly 90 degrees and an orbital period of approximately 105 minutes. Mission duration is estimated for 3 years.

The requirements for Polar Bear were similar to those of HILAT: Raw and Summary tapes were to be archived; data was to be quality checked and prepared for shipment to outside agencies; and a scintillation data base was to be created. In addition, however, a data base was to be created for the Auroral Ionospheric Remote Sensor (AIRS). Since the common requirements between HILAT and Polar Bear were discussed in the preceding chapter, discussions here will concern Polar Bear in general and AIRS in particular.

The telemetry system aboard the vehicle is similar to HILAT and is refered to as the Science Data Formatter (SDF). The SDF outputs science data at a rate of 4.098kbps. The spacecraft is 3 axis stabilized to +/- 10 degrees in the pitch, yaw and roll axes.

The payload for Polar Bear includes the AIRS, the beacon and the triaxial fluxgate magnetometer. The AIRS is a more sophisticated version of the Auroral Ionospheric Mapper (AIM) detector flown on HILAT. It obtains simultaneous multispectral UV and visual images for both daylight and night operations. The beacon, similar in design to the one flown on HILAT, is used to measure scintillation effects at radio frequencies used for radar and communications. The magnetometer is also of similar design to the system used on HILAT. It measures field aligned currents as well as providing a means of attitude determination along with the digital sun sensor. These three instruments will be operated concurrently in real time mode over the remote stations located in the northern polar region. The AIRS, however, can be operated independently over mid-latitude regions.

There are, thus, great similarities between Polar Bear and HILAT. The Polar Bear Scientific Satellite Data Analysis System (SSDAS) consists of a modified version of the HILAT system. Many of the modular routines developed for HILAT have direct application for Polar Bear.

The input data for SSDAS applications is the Summary Tape which is in a similar format to that used for HILAT.

The AIRS data base is being archived on digital tape. A log of digital tape number and the passes contained on the tape is maintained. Separate logs will exist for each of the remote stations receiving the AIRS data.

The AIRS sensor consists of four integrated detectors each of which obtains 326 pixel values per line scan. The time duration of a line scan is 2.9987 seconds which is readout over 6 SDF telemetry frames. Also contained in these 6 frames is AIRS housekeeping data, the sequencer values and status words. The instrument can be operated in any of three modes: imaging, spectrometer and photometer. A high degree of flexibility exists for commanding the wavelengths to be selected for detectors 1 and 2 in imaging and photometer mode. Detectors 3 and 4 can be commanded to either of two fixed wavelengths.

In imaging mode, a mirror line scan consisting of 326 pixels takes place for each of the 4 detectors. Each step in the line scan corresponds to approximately .4 degrees. Although the instrument actually moves through 336 steps, no data is taken in the first and last 5 steps. Only the data from the 326 good pixels is readout to telemetry. The full mirror scan corresponds to plus and minus 67.2 degrees from nadir. At the end of each forward scan, the mirror direction is reversed by stepping the motor at 4 times the forward scan rate.

In photometer mode, the mirror is fixed at nadir. As in imaging mode 336 pixels are readout over 6 SDF telemetry frames but valid photometer data is obtained for all pixels except the first and last 5. In this mode, detectors 1 and 2 are used for VUV measurements while detectors 3 and 4 are for UV measurements.

Spectrometer mode has the mirror fixed at nadir while the wavelength range is swept. Detector 1 covers the wavelength range from 1189 to 2164 Angstroms while detector 2 scans the range from 924 to 1924 Angstroms. Of the 336 pixel values readout over the 6 SDF telemetry frames, valid spectrometer data is obtained from pixels 6 through 331. In this mode, detectors 3 and 4 operate as photometers.

The pixel data is in 8 bit compressed count form. The exponent (3 most significant bits) and mantissa (5 least significant bits) must be extracted and used in the decompression algorithm in order to obtain counts per accumulation period.

The AIRS data base was designed with sufficient flexibility to be used in follow on analyses and display routines. The data base contains structured records corresponding to a full set of pixel readouts starting at pixel 1 and ending at the last pixel.

Decompressed counts are stored in packed form to minimize storage requirements. The frames are time tagged to the beginning of the scan. Selected ephemeris and magnetic parameters as well as vehicle pitch, yaw and roll are extracted from the Time/Geometry/Magnetic Field records on the summary tape and stored in each data base record. In addition, the magnetometer data is stored in compressed and packed form to be readily available in the event it is needed for correlation with the AIRS data. By storing the magnetometer data in compressed counts data base compaction is further enhanced.

All instrument housekeeping data is included in the data base.

Each data base file represents data from one pass. A history file of orbit start and stop times along with instrument mode is created using automated procedures. This file is useful in providing a history of instrument operations and also for selecting particular passes for studies.

Since there is a great similarity between the AIRS and the AIM sensor flown on HILAT, techniques developed to handle the AIM data were directly applied to the AIRS. Moreover, many of the computer modules in the HILAT library of subroutines have direct application while others required only minor modification to have applicability.

The AIRS telemetry consists of 221 8-bit words per SDF frame. A full set of AIRS readouts is acquired over 6 telemetry frames. The first of the 221 words in each frame contains the AIRS frame counter which cycles from 1 to 6 along with a sequencer A value. This word is refered to as the Identifier word. There are five A sequencers and one B sequencer which are used to control the instrument.

In lines 1-5, the telemetry format is the same: the identifier word followed by 220 pixel readouts. The order of the pixel data is as follows for each detector: 1,2,3,4,1,2,...4. Thus there are 55 readouts for each of the four detectors on each of the first 5 lines of telemetry. Line six begins the same way as the other 5 lines but ends in a different way. The first word is the identifier word; the next 204 words contain pixel data (structured as in the previous 5 frames); words 206-221 contain AIRS housekeeping and status information. There are 16 AIRS housekeeping words which are readout in 4 groups of 4 words.

The prime functions of the A sequencers are:

SEQ NO.	FUNCTION
A0	Selects one of 16 wavelength positions for imaging or photometer mode.
A1	Selects imaging, photometer or spectrometer mode.
A2	Controls backup functions such as increasing power for spectrometer grating motor.
A3	Selects test modes such as dark shutter and optical
A4	Switches power off to any of the detectors
A5	Controls spectrometer grating mode selection and other housekeeping functions.

The B sequencer is used to select the A sequencer which is to be commanded.

The correlation between the AIRS frame counter and the A sequencer number is:

Frame Counter	A Sequencer
1	A0
2	A1
3	A2
4	A3
5	A4
6	A5 .

For sequencer A0, the sequencer value reflects the wavelength selected for detectors 1 and 2.

Seq A0 value	Det 1/Det 2 (Angstroms)
0	1216/ 976
1	1304/1064
2	1356/1116
3	1410/1170
4	1456/1216
5	1493/1253
6	1544/1304
7	1596/1356
8	1625/1385
9	1654/1414
10	1670/1430
11	1733/1493
12	1750/1510
13	1833/1593
14	1910/1670
15	1990/1750 .

Sequencer A1 is used to determine instrument scan mode:

Seq A1 value	Mode(I=Imaging,S=Spectrometer,P=Photometer)
0	I
1	S
2	I
3	P
4	I
5	S
6	I
7	P
8	I
9	S
10	I
11	P
12	I
13	S
14	I
15	P .

Sequencer A3 is used to determine the instrument test mode.

Seq. A3 value	Test Mode
0	Normal
1	Dark Shutter
2	Normal
3	Optical Test
4	Normal
5	Extended Dark
6	Normal
7	Optical Test
8	Normal
9	Dark Shutter
10	Normal
11	Optical Test
12	Normal
13	Extended Dark
14	Normal
15	Optical Test

In addition to the wavelengths for detectors 1 and 2 which are obtained from sequencer A0, other wavelengths may be selected. The selected wavelength can be determined by use of the A1 and A3 sequencers.

The AIRS data base routine performs the following prime functions:

1. Find the first occurance of a line counter value of 1. (This will initiate processing for the pass.)

2. Test for telemetry dropout and 1's fill within scans as necessary. Missing frames can be determined by the use of the AIRS line counter and the SDF frame counter.

3. Interpolate ephemeris/magnetic/attitude data to the time at the beginning of the line scan.

4. Extract and decompress pixel counts for each detector.

5. Structure data by detector in packed word form.

6. Extract and retain AIRS status and housekeeping data. These words will be kept in telemetry counts.

7. Extract and retain data from the science magnetometer.

8. Create 2 data base header records. The first contains a summary of instrument status at the beginning of the pass. The second contains ephemeris parameters which may be required in future AIRS analyses.

9. Create structured AIRS data base records designed to allow for easy input to analysis routines yet provide for data compression.

The AIRS data base format is contained in the appendix.

4.0 Accelerometer Analyses

The problem presented to the laboratory was to develop and implement analytic techniques necessary to create and maintain neutral atmospheric density data bases for three satellite missions refered to as NP5, NP6 and S85-1. Analysis and software system development was carried out in order to process data from the triaxial accelerometer systems onboard these satellites. Atmospheric density was obtained in the altitude region from 170 km to 240 km. These data were merged with satellite ephemeris parameters and stored in geophysical history data bases for later analysis.

The triaxial accelerometer systems were designed to determine atmospheric density by measuring the satellite deceleration caused by aerodynamic drag. Each system consisted of three accelerometer sensors mounted on orthogonal axes. Thus highly accurate measurements of aerodynamic accelerations acting on the satellite's long track (z), cross track (x) and radial direction (y) were made.

The problem consists of an analysis of calibration data for the accelerometers, calculation of drag coefficients for the individual satellites, removal of bias and noise effects from the accelerometer signal, calculation of ephemeris parameters, computation of atmospheric model values and their comparison to derived values, and the calculation of density.

Each acceleration sensor consisted of an electrostatically suspended proof mass which was also electrostatically rebalanced along a sensitive axis with a force equal to the applied acceleration. Any acceleration of the sensor covering caused the proof mass to move in the opposite direction relative to the covering. The rate at which pulses of a given voltage were required to restore the proof mass to the center position was directly proportional to the applied acceleration along the sensitive axis.

For each axis of the accelerometer, the output signal was generated as pulse counts, representing the integrated acceleration over the sampling period of about 2 seconds. The calibration data consisted of tables of pulse counts per second versus acceleration for known gravitational accelerations applied to each axis of the accelerometer. Data was taken at different ambient temperatures for the accelerometer to determine the possible temperature dependence of the counts-to-acceleration conversion.

The scale factor is defined as the ratio of counts to acceleration. Polynomial best fits of various orders were performed for variation of scale factor with temperature for each of the various operating ranges.

In order to obtain the density data from the instrument output pulse rate, the following conditions were required: the data was merged with ephemeris and satellite aspect data; a correction was applied to the measured pulse rate to account for temperature sensitivity and scale factors; the pulses due to air drag were separated from those due to all other causes; the drag acceleration was determined; and the density calculated.

For each axis of the accelerometer, the measured acceleration is related to the atmospheric density (rho) and apparent atmospheric velocity (V) according to:

$$A = \frac{\text{rho}\ V^2\ C\ (\vec{V})}{2M} , \qquad (4\text{-}1)$$

where: $C\ (\vec{V})$ is the drag coefficient for axis i (i=x,y,z), and M is the satellite mass.

Because the drag coefficient cannot be determined by direct measurement for such low densities and high velocities, it has been calculated from a theoretical representation of the satellite shape. The computation of drag coefficients was dependent on the ambient temperature of the gas, it's mean molecular weight and the velocity components relative to the accelerometer coordinate system. These results were incorporated into subroutines for use in the bias determination and density calculation stages of the processing.

In addition to the accelerations produced by atmospheric forces, the accelerometers also respond to satellite vibrations, attitude and orbital dynamics, and the accelerometer output signal contains noise intrinsic to the electronics. Because the output signal is sampled at a rate of about 0.5 Hz, the extraneous signals can make a contribution to the slowly varying atmospheric signal through aliasing, although some attenuation of aliased signal does occur because of the 2-second integration time per sample. High-frequency noise is further reduced by an electronic filter associated with the accelerometer electronics. This is done prior to sampling so that contributions at the aliased frequency are also eliminated.

The attitude adjustments and vibrations were treated by low pass digital filtering of the various accelerometer signals. The parameters chosen for the low-pass filters for the individual axes were:

	Pass Bandwidth	Transition Bandwidth
x-axis	0.05 Hz	0.0167 Hz
y-axis	0.05 Hz	0.0167 Hz
z-axis	0.05 Hz	0.0167 Hz

In the case of the NP5 vehicle an additional data base was created using a low-pass filter with the following characteristics:

	Pass Bandwidth	Transition Bandwidth
x-axis	0.005 Hz	0.005 Hz
y-axis	0.005 Hz	0.005 Hz
z-axis	0.010 Hz	0.010 Hz

Extraordinary noise contributions could not be treated by digital filtering, and were of such a magnitude as to overwhelm the aerodynamic signal. Data segments affected by these were simply skipped when density values were calculated.

One characteristic of the accelerometers was a non-zero response to zero aerodynamic acceleration while in orbit. The bias values are different for each of the three accelerometer axes and are not constant as a function of time. Thus, a method of removing these bias values from acceleration signal was needed.

For each pass, atmospheric drag at satellite apogee contributed to the accelerometer signal. This contribution was estimated by using a model atmospheric density (Jacchia 1971) and equation (4-1) to compute expected drag accelerations for each accelerometer axis in the vicinity of apogee. For each axis, the bias was calculated as the difference between the measured signal from the accelerometer and the corresponding expected drag acceleration. Thusly, averaged biases were taken over various time periods centered on apogee.

The resulting bias values showed some scatter about a much slower trend over each vehicle's lifetime. This scatter was attributed to the estimations of the atmosphere model and noise in the accelerometer signal, after filtering. Thus, a smooth fit to the data was used to represent the bias value. For each vehicle and accelerometer axis, polynomial fits were performed over vehicle lifetime.

Accelerometer data was merged with orbital ephemeris data based on corresponding time values, although orbital data was interpolated from values spaced at 60 second intervals to the roughly 2 second interval of the accelerometer data. A quadratic interpolation process was used for this evaluation for the fundamental ephemeris parameters (e.g., latitude, longitude, altitude) and also for some derived parameters (e.g., heading direction, velocities). Other derived parameters were computed on a point- by-point basis from more fundamental parameters (e.g., magnetic local time, local time).

The following parameters were added to the accelerometer data base using the supplied ephemeris values:

a) altitude
b) latitude
c) longitude (positive east)
d) geocentric velocity (km/sec)
e) local time .

The remaining parameters were derived from the ephemeris values:

a) velocity with respect to atmosphere (km/sec)
b) angle between geocentric and atmospheric velocities
c) solar declination
d) x-direction relative to North
e) magnetic local time .

Density values were derived from the measured accelerations using the following equation,

$$rho = \frac{2\ M\ Az}{V^2\ Cz(\vec{V})}, \quad \text{where}$$

Az is the aerodynamic acceleration for axis z (long track),

M is the satellite mass,

$\vec{V}$ is the total atmospheric velocity relative to the satellite,

V is the satellite velocity,

$Cz(\vec{V})$ is the drag coefficient for axis z, and

rho is the atmospheric density.

The total atmospheric velocity relative to the satellite is given by

$\vec{V} = -\vec{V}g+\vec{V}a+\vec{V}w$, where

$\vec{V}g$ = geocentric velocity of the satellite,

$\vec{Va}$ = rotational contribution of atmospheric velocity, and
$\vec{Vw}$ = wind contribution of atmospheric velocity.

For this study, the wind contribution being small in relation to the known contribution $-\vec{Vg}+\vec{Va}$, was ignored.

A set of existing computer routines were modified and adapted to process each system, uniquely. In the case of NP5 and NP6, digital tapes, refered to as DMA tapes, containing raw and filtered accelerometer data were received at AFGL. In the case of S85-1, LPARL tapes containing raw accelerometer data were provided. The data was processed on a daily basis to the final density stage. Associated displays, listings and data bases were created as noted below.

For each day in question, the filtered and raw data was reformatted onto a magnetic tape. In the case of S85-1, the raw data was filtered initially.

Time history displays were produced which exhibit the data for each of the 3 accelerometer axes, along with temperature on a daily basis. The data was then merged with appropriate ephemeris parameters and stored on a magnetic tape. A decimated merged data base was stored on permanent file for further plotting. The merged data along with appropriate Kp, Ap and flux values was accessed in the generation of bias values for the 3 axes on an orbit-by-orbit basis and a daily average calculation. The bias calculations were based on fitting the filtered data to model drag components over 500 seconds of apogee data for each orbit. In the case of S85-1, 180 seconds of apogee data were used in the averaging process. Paper plots and listings were generated for each day in question. Also, the decimated merged data file was accessed in the generation of paper plots exhibiting filtered outputs for each of the 3 axes on an orbit-by-orbit basis. At this point, the bias files (orbit-by-orbit and daily average files) augmented by the day being processed were updated. The files were sorted day-by-day, EOR's removed and duplicate days eliminated prior to usage by the density program.

On the basis of 'quiet' vs. all days, plots exhibiting bias values as a function of time were generated resulting in a bias fit technique being used for density calculations. Based on a study of the raw and filtered data plots, skip times, necessary to the density program run, were determined for each day. A density data base was created on tape and on permanent file with the JACCHIA program. Paper plots and listings were generated from the density file exhibiting density and normalized density and selected model and ephemeris parameters as functions of time on an orbit-by-orbit basis. Microfiche displays of density as a function of altitude were generated. In the case of S85-1, microfiche displays were not required. Finally, follow on density plots (normalized with respect to the MSIS model) were generated for a wave structure study.

Raw and filtered digital data were provided for 156 days of NP5 and 160 days of NP6. A total of 150 days of NP5 and 150 days of NP6 were processed to the final density stage. The remaining 6 days of NP5 and 10 days of NP6 were unprocessable.

For S85-1, 78 days of raw data were provided for processing. Each day contained approximately ten 28 minute passes centered on maximum north latitude, six 20 minute passes centered on perigee and eight 6 minute passes centered on apogee for bias determination. For each data base tape, accelerometer words, clocks and marker bits were stripped off, and the data was time correlated and reconstructed in proper time sequence. The accelerometer words were then calibrated to mg's and temperature and data base files were created. For this purpose calibrations and clock correlation factors were utilized. Analyses and associated computer routines were developed and successfully utilized to convert the time correlated raw data to filtered data. Raw and filtered data tapes were thereby generated in the same format as the reformatted DMA tapes for the 78 days of interest. A total of 74 of the 78 days were subsequently processed to the final density stage. The remaining 4 days were unprocessable.

The density data bases, noted above, were generated at high data rate outputs (a point every 4 seconds). These data bases provided the opportunity to store data from many orbits into common data banks which were stuctured to allow global studies to be performed.

Tape formats associated with raw/filtered accelerometer data, merged ephemeris data and model/density data are contained in the appendix.

5.0 Shuttle Analyses

Analysis systems have been developed and implemented for space shuttle missions. Data bases consisting of experiment data along with shuttle related parameters have been successfully created. Systematic techniques analagous to those described in preceding sections were employed for the experiment data. New techniques were necessary for the data products received at AFGL from NASA. This chapter will discuss the NASA products.

For early missions two sets of tapes were typically received. The preliminary data (on tapes refered to as CP011F) was received shortly after landing. The CP011F tapes contained unprocessed orbiter data as it was downlinked over several asynchronous PCM systems. Time tagging was accomplished by using appropriate delta time values contained on the records. The final tapes (CBET04) contained smoothed and processed data but these tapes begin to arrive approximately 12 weeks after the mission. On these two tape types, the orbit, attitude and ancillary data are blocked together in large records.

For recent missions, the NASA data has been received on Shuttle POCC Interface Facility (SPIF) tapes. These tapes are similar to a combination of CP011F and CBET04 tapes but the orbit, attitude and ancillary data is interlaced on each file. Moreover, the tapes were generated on a VAX computer and the standard byte reversal techniques had to be applied before the informational parameters could be extracted. Analytic techniques developed for the CP011F and CBET04 tapes had direct application for the SPIF tapes.

Routines and techniques were developed for the extraction of parameters from these NASA products. This, however, is frequently only the first phase of the effort since additional analyses must be performed in order to provide the experimenter with the parameters which are required.

With respect to the ephemeris data, the preliminary Johnson Space Center (JSC) CP011F tape contains two sets of vehicle position and velocity vectors (referred to as state vectors) in an Earth Centered Inertial (ECI) true of date coordinate system. This coordinate system (XYZ) is right handed, where X is the component in the direction of the Vernal Equinox; Z is in the direction of the North pole; and Y = ZxX. One set of provided vectors consists of the filtered components outputted by the telemetry, and the others are the current state vectors of the spacecraft. The CBET04 JSC tape contains processed information. The spacecraft's state vector is provided in many coordinate systems such as mean of 50 ECI, true of date ECI, and Aries true of date polar.

Existing ephemeris computation routines were then used to produce a standardized ephemeris file. This ephemeris file is created at a sufficiently high sample rate so that it can be interpolated upon whenever necessary without loss of data structure.

The direct correlation between ephemeris parameters and generated geomagnetic and solar models is well known. Since experimenters often require magnetic pitch angles to properly interpret their sensor data, various geomagnetic parameters have to be determined. Thus, using a standardly formatted ephemeris file as input, the model geomagnetic field parameters can be determined using the appropriate set of IGRF eighth degree Gaussian coefficients. The proper set depends upon the year of the flight. For each time related value, the cartesian components of the Earth's magnetic field (North, East, and vertical), the magnetic declination and inclination (dip) angles, can be determined. The spatial parameters commonly required include the total magnetic field intensity and the L shell (in Earth radii). Other geomagnetic parameters which can be computed are geomagnetic local time, geomagnetic latitude and longitude, and corrected geomagnetic latitude, longitude, and local time.

For certain sensors meaningful interpretation of the instrument's output can be accomplished only when the orientation of the sensor is known. The orientation of the sensing axis of an experiment with respect to a fixed coordinate system in space is referred to as its attitude.

The NASA CP011F tape provides vehicle attitude information in the form of quaternions which relate the vehicle's axes in the M50 coordinate system to the local vertical, local horizontal (LVLH) coordinate system. Vehicle pitch, yaw, and roll in the M50 coordinate system are also provided.

The CBET04 tape contains processed and filtered results at a fixed data rate. This tape contains attitude of the vehicle axes in quaternion or matrix form. This data is given in the M50 coordinate system. The attitude of the shuttle axes is given in the form of 3x3 matrices or quaternions. Euler's theorem states that any finite rotation of a rigid body can be expressed as a rotation through some angle about a fixed axis, namely a quaternion. Thus, any three axis Euler rotation 3x3 matrix can be described as a rotation by some angle about some fixed axis.

A three angle Euler rotation, which relates system A to system B, can be represented by a 3x3 rotation matrix R comprised of elements R_{ij} such that

$$B = \begin{pmatrix} R_{11} & R_{12} & R_{13} \\ R_{21} & R_{22} & R_{23} \\ R_{31} & R_{32} & R_{33} \end{pmatrix} A \quad .$$

The quaternion is a vector with four components which relates system A to system B. It is denoted

$$QBA = (q_1, q_2, q_3, q_4) \quad .$$

The rotation angle and the single Euler axis that defines the quaternion relationship between the two systems can be determined from the 3x3 matrix components. The rotation angle is given by

$$\cos a = 1/2\ (R_{11} + R_{22} + R_{33} - 1.) \quad ,$$

and the single Euler axis

$$E = (EX, EY, EZ)$$

where

$$EX = (R_{23} - R_{32})/2 \sin a$$

$$EY = (R_{31} - R_{13})/2 \sin a$$

$$EZ = (R_{12} - R_{21})/2 \sin a \quad .$$

Thus $QBA = (q_1, q_2, q_3, q_4)$ is given by

$$QBA = (\cos(a/2), EX \sin(a/2),\ EY \sin(a/2),\ EZ \sin(a/2)) \quad .$$

Similarly, the 3x3 rotation matrix can be determined from the quaternion. In this case, the transpose must be taken in order to obtain the proper matrix. The 3x3 matrix determined from $QBA = (q_1, q_2, q_3, q_4)$ is

$$R_{11} = q_1q_1 + q_2q_2 - q_3q_3 - q_4q_4$$

$$R_{12} = 2(q_2q_3 - q_1q_4)$$

$$R_{13} = 2(q_2q_4 + q_1q_3)$$

$$R_{21} = 2(q_2q_3 + q_1q_4)$$

$$R_{22} = q_1q_1 - q_2q_2 + q_3q_3 - q_4q_4$$

$$R_{23} = 2(q_3q_4 - q_1q_2)$$

$$R_{31} = 2(q_2q_4 - q_1q_3)$$

$$R_{32} = 2(q_3q_4 + q_1q_2)$$

$$R_{33} = q_1q_1 - q_2q_2 - q_3q_3 + q_4q_4 \quad .$$

The most basic coordinate system used is the body axis coordinate system. In this system X is parallel to the orbiter structural axis positive toward the nose, Y is parallel to the right wing, and Z is positive out of the bottom of the orbiter. The Euler rotation associated with this system is a pitch, yaw, roll sequence.

The vehicle body system is frequently required to be expressed in the Local Vertical Local Horizontal (LVLH) coordinate system (or landing reference frame). This is a local orbital coordinate system where the Z axis goes from the vehicle to center of the Earth, Y axis is normal to the orbital plane and opposite sense of the vehicle's momentum vector, and X = Y x Z.

For attitude given in the Mean 1950 (M50) coordinate system, X is directed towards the mean vernal equinox of 1950, the Z is in the direction of the mean 1950 North celestial pole, and Y completes the right hand coordinate system. Another frequently required attitude reference frame is the true of date ECI coordinate system. In this coordinate system X is the direction of the actual vernal equinox, Z is in the direction of the true North celestial pole, and Y completes the right hand system.

Since different parameters can be expressed in various coordinate systems, a series of matrix transformations has been developed to allow for mappings between systems. These routines have been developed in modular form to keep within the overall SSDAS philosophy.

Transformation matrices relating the M50 reference frame to the true of date, the true of date to the LVLH, and the true of date to the local cartesian system exist.

The (X_L, Y_L, Z_L) axes of the LVLH are determined from the true of date state vectors. R is the position of the shuttle from the center of the Earth in ECI system and it is given by

$$R = iR1 + jR2 + kR3$$

Let the absolute value of a vector, R, be denoted by [R], then

$$[R] = \sqrt{R1^2 + R2^2 + R3^2} \quad .$$

Then expressing R as a unit vector,

$$R = R/[R] = iR1/[R] + jR2/[R] + kR3/[R] \quad .$$

The vehicle's velocity vector is given by

$$V = iV1 + jV2 + kV3$$

where [V] is defined similarly.

In the LVLH coordinate system

$$Z_L = -R/[R]$$
$$Y_L = -(RxV)/[(RxV)]$$
$$X_L = Y_L \times Z_L \quad .$$

Then (XL,YL,ZL) in matrix form is given by

$$\begin{pmatrix} X_L \\ Y_L \\ Z_L \end{pmatrix} = \begin{pmatrix} c_{11} & c_{12} & c_{13} \\ c_{21} & c_{22} & c_{23} \\ c_{31} & c_{32} & c_{33} \end{pmatrix} \begin{pmatrix} i \\ j \\ k \end{pmatrix} \text{ or } \begin{pmatrix} X_L \\ Y_L \\ Z_L \end{pmatrix} = C \begin{pmatrix} i \\ j \\ k \end{pmatrix}$$

Taking the transpose

$$\begin{pmatrix} i \\ j \\ k \end{pmatrix} = C^T \begin{pmatrix} X_L \\ Y_L \\ Z_L \end{pmatrix} \quad .$$

Thus, by substituting, the vehicle axes are now represented in the LVLH coordinate system by

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = A \begin{pmatrix} i \\ j \\ k \end{pmatrix} = AC^T \begin{pmatrix} XL \\ YL \\ ZL \end{pmatrix}$$

Similar transformation matrices have been developed for the determination of shuttle pitch, yaw and roll.

The attitude of the LOS of the vehicles' axes is normally determined in all the above coordinate systems for the CP011F and CBET04 data. Additionally, the LOS of probes aboard the shuttle are normally computed.

Attack angles and tangent height calculations are frequently required by experimenters for proper data interpretation.

Attack angles are defined as the angles between the LOS of a probe or axis and a given vector. The more frequently required attack angles involve the angle between a sensor LOS and the magnetic field, velocity vector or the sun vector.

Tangent height is the minimum altitude above the surface of the Earth which an unrefracted light ray coming from behind the Earth through the CO_2 layer to the spacecraft. Thus, tangent height is apparent height (at the horizon) from which radiation is coming. Tangent height calculations assume an oblate spheroid earth model and is a geometric solution rather than the method of closest approach. These calculations also require attitude of the LOS in the local cartesian system, (elevation and azimuth angles), the vehicle's positional data of latitude, altitude and distance from the center of Earth to vehicle, and an equation to calculate the radius of the Earth as a function of the geodetic latitude.

A final irreducible data base consisting of attitudinal, positional, and geomagnetic parameters was created for each mission. This data base was designed to include all the parameters necessary for the satisfaction of experimenter requirements. Moreover, the data base is constructed with an even time spacing to facilitate interpolation.

With respect to the ancillary data, techniques and computer routines have been developed for the determination of thruster firings, occurances of water dumps, OMS burns. These parameters as well as others such as fuel cell purges and relief of the cryogenic supplies are considered to be contaminants since they can drastically effect sensor outputs. Typically, a full mission data base of thruster firings and water dumps was created.

Onboard the orbiter there are 38 main and 6 Vernier thrusters which are included in the Reaction Control System (RCS). Twelve main jets and 2 Vernier thrusters are located forward, and 24 main jets (2 systems of 12 pairs) and 4 Vernier thrusters are located in the aft section. Knowledge of precisely which thruster (or thrusters) were fired at any instant of time can be essential to data interpretation.

There are two water storage systems onboard the vehicle. One is a supply water system (which consists of six tanks) and the other is a waste water system (one tank). Only one tank can be dumped at a time. The waste water tank is full at launch and is dumped in orbit, and then the tank's water level is restored to its condition at launch. Bi-levels within the spacecraft's telemetry indicate the occurrance and type of water dump in progress. Analog monitors onboard the spacecraft indicate the percentage of water in each tank. Knowing the capacity of each tank allows the calculation of the amount of water being dumped. Thus, for any water dump the following information can be determined; the type of water dump (waste or supply); the start and end time of each dump; the duration and quantity of water discharged at any instant while the dump is in progress; and the total amount of water expelled during the dump.

Data bases structured for use on the AFGL Control Data Cyber computer have been archived.

APPENDIX A

HILAT TAPE LOG SAMPLE

HILAT SUMMARY CHURCHILL 87/04/15.

TAPE/FILE		YEAR	DAY	SEC1-SEC2	HHMM:SS-HHMM:SS
CU0078/	1	84	138	41937-42432	1138:57-1147:12
	2	84	138	67017-67542	1836:57-1845:42
	3	84	138	73111-73741	2018:31-2029:01
	4	84	138	79277-79697	2201:17-2208:17
	5	84	139	34171-34771	0929:31-0939:31
	6	84	139	40337-40877	1112:17-1121:17
	7	84	139	71546-72176	1952:26-2002:56
	8	84	139	77693-78188	2134:53-2143:08
	9	84	140	32626-33211	0903:46-0913:31
	10	84	140	38749-39319	1045:49-1055:19
	11	84	141	31079-31634	0837:59-0847:14
	12	84	141	37165-37765	1019:25-1029:25
	13	84	141	68418-69033	1900:18-1910:33
	14	84	141	74538-75123	2042:18-2052:03
	15	84	142	29546-30056	0812:26-0820:56
	16	84	142	35588-36203	0953:08-1003:23
	17	84	142	41858-42278	1137:38-1144:38
	18	84	142	66856-67441	1834:16-1844:01
	19	84	142	72965-73580	2016:05-2026:20
	20	84	143	28027-28477	0747:07-0754:37
	21	84	143	34018-34633	0926:58-0937:13
	22	84	143	40246-40726	1110:46-1118:46
CU0083/	1	84	143	65296-65851	1808:16-1817:31
	2	84	143	71396-72026	1949:56-2000:26
	3	84	144	32457-33072	0900:57-0911:12
	4	84	144	38643-39168	1044:03-1052:48
	5	84	144	63742-64252	1742:22-1750:52
	6	84	145	62190-62640	1716:30-1724:00
	7	84	145	68268-68898	1857:48-1908:18
	8	84	145	74405-74945	2040:05-2049:05
	9	84	146	29353-29923	0809:13-0818:43
	10	84	146	35456-36041	0950:56-1000:41
	11	84	146	66703-67333	1831:43-1842:13
	12	84	147	33876-34491	0924:36-0934:51
	13	84	147	71256-71871	1947:36-1957:51
	14	84	148	32306-32921	0858:26-0908:41
	15	84	148	69687-70317	1921:27-1931:57
	16	84	149	30736-31352	0832:16-0842:32
	17	84	149	62024-62564	1713:44-1722:44
	18	84	149	68119-68764	1855:19-1906:04
	19	84	150	29181-29796	0806:21-0816:36
	20	84	150	35345-35900	0949:05-0958:20
CU0088/	1	84	150	60469-60949	1647:49-1655:49
	2	84	150	66553-67198	1829:13-1839:58
	3	84	150	72703-73213	2011:43-2020:13
	4	84	151	27631-28216	0740:31-0750:16
	5	84	151	33754-34339	0922:34-0932:19
	6	84	151	64990-65635	1803:10-1813:55

1 HILAT SUMMARY CHURCHILL 87/04/15.

TAPE/FILE		YEAR	DAY	SEC1-SEC2	HHMM:SS-HHMM:SS
CU0088/	7	84	151	71121-71691	1945:21-1954:51
	8	84	152	26087-26657	0714:47-0724:17
	9	84	152	32172-32772	0856:12-0906:12
	10	84	152	63429-64044	1737:09-1747:24
	11	84	152	69549-70149	1919:09-1929:09
	12	84	153	24555-25080	0649:15-0658:00
	13	84	153	30590-31220	0829:50-0840:20
	14	84	153	24555-25080	0649:15-0658:00
	15	84	153	30590-31220	0829:50-0840:20
	16	84	154	29024-29654	0803:44-0814:14
	17	84	154	66406-67051	1826:46-1837:31
	18	84	155	27462-28092	0737:42-0748:12
CU0092/	1	84	155	58752-59262	1619:12-1627:42
	2	84	155	64839-65484	1800:39-1811:24
	3	84	155	70997-71477	1943:17-1951:17
	4	84	156	25909-26524	0711:49-0722:04
	5	84	156	32053-32623	0854:13-0903:43
	6	84	156	57195-57660	1553:15-1601:00
	7	84	156	63275-63920	1734:35-1745:20
	8	84	156	69419-69959	1916:59-1925:59
	9	84	157	24361-24946	0646:01-0655:46
	10	84	157	30466-31066	0827:46-0837:46
	11	84	157	61713-62343	1708:33-1719:03
	12	84	157	67839-68424	1850:39-1900:24
	13	84	158	22820-23375	0620:20-0629:35
	14	84	158	28883-29498	0801:23-0811:38
	15	84	158	60152-60767	1642:32-1652:47
	16	84	158	66268-66883	1824:28-1834:43
	17	84	159	21293-21788	0554:53-0603:08
	18	84	159	27312-27942	0735:12-0745:42
	19	84	159	33559-34024	0919:19-0927:04
CU0096/	1	84	159	58593-59178	1616:33-1626:18
	2	84	159	64696-65341	1758:16-1809:01
	3	84	160	19780-20215	0529:40-0536:55
	4	84	160	25741-26371	0709:01-0719:31
	5	84	160	31952-32477	0852:32-0901:17
	6	84	160	63128-63788	1732:08-1743:08
	7	84	161	24186-24816	0643:06-0653:36
	8	84	161	30353-30923	0825:53-0835:23
	9	84	161	61564-62224	1706:04-1717:04
	10	84	162	22637-23237	0617:17-0627:17
	11	84	162	28756-29356	0759:16-0809:16
	12	84	162	60002-60647	1640:02-1650:47
	13	84	162	66133-66703	1822:13-1831:43
	14	84	163	21091-21661	0551:31-0601:01
	15	84	163	27172-27787	0732:52-0743:07
	16	84	164	19561-20086	0526:01-0534:46
	17	84	164	25595-26225	0706:35-0717:05

HILAT SUMMARY CHURCHILL 87/04/15.

TAPE/FILE	YEAR	DAY	SEC1-SEC2	HHMM:SS-HHMM:SS
CU0096/18	84	164	31866-32316	0851:06-0858:36
CU0100/ 1	84	164	56881-57481	1548:01-1558:01
2	84	164	62986-63616	1729:46-1740:16
3	84	165	18038-18518	0500:38-0508:38
4	84	165	24030-24675	0640:30-0651:15
5	84	165	30254-30764	0824:14-0832:44
6	84	165	55320-55890	1522:00-1531:30
7	84	165	61420-62065	1703:40-1714:25
8	84	166	22467-23097	0614:27-0624:57
9	84	166	28652-29207	0757:32-0806:47
10	84	166	53763-54288	1456:03-1504:48
11	84	166	59851-60511	1637:31-1648:31
12	84	166	66009-66504	1820:09-1828:24
13	84	167	20911-21526	0548:31-0558:46
14	84	167	58289-58934	1611:29-1622:14
15	84	167	64426-64981	1753:46-1803:01
16	84	168	19363-19963	0522:43-0532:43
17	84	168	25465-26080	0704:25-0714:40
18	84	168	56726-57356	1545:26-1555:56
19	84	169	23887-24517	0638:07-0648:37
CU0104/ 1	84	169	55164-55779	1519:24-1529:39
2	84	169	61277-61907	1701:17-1711:47
3	84	170	16298-16808	0431:38-0440:08
4	84	170	22312-22957	0611:52-0622:37
5	84	170	28560-29040	0756:00-0804:00
6	84	170	53602-54187	1453:22-1503:07
7	84	170	59708-60353	1635:08-1645:53
8	84	171	20751-21396	0545:51-0556:36
9	84	171	26952-27492	0729:12-0738:12
10	84	171	52046-52586	1427:26-1436:26
11	84	171	58145-58790	1609:05-1619:50
12	84	171	64305-64755	1751:45-1759:15
13	84	172	19191-19821	0519:51-0530:21
14	84	172	25353-25923	0702:33-0712:03
15	84	172	50492-50987	1401:32-1409:47
16	84	172	56577-57237	1542:57-1553:57
17	84	173	17640-18255	0454:00-0504:15
18	84	173	23762-24377	0636:02-0646:17
19	84	173	55015-55660	1516:55-1527:40
20	84	173	61141-61711	1659:01-1708:31
[illegible]/ 1	84	174	16099-16684	0428:19-0438:04
2	84	174	22182-22812	0609:42-0620:12
3	84	174	53453-54083	1450:53-1501:23
4	84	174	59571-60186	1632:51-1643:06
5	84	175	20602-21247	0543:22-0554:07
6	84	175	51889-52489	1424:49-1434:49
7	84	175	57999-58629	1606:39-1617:09

1 HILAT SUMMARY CHURCHILL 87/04/15.

TAPE/FILE	YEAR	DAY	SEC1-SEC2	HHMM:SS-HHMM:SS
CU0108/ 8	84	176	19032-19677	0517:12-0527:57
9	84	176	56432-57077	1540:32-1551:17
10	84	177	17472-18117	0451:12-0501:57
11	84	177	23657-24212	0634:17-0643:32
12	84	177	48770-49295	1332:50-1341:35
13	84	177	54866-55511	1514:26-1525:11
14	84	177	61020-61500	1657:00-1705:00
15	84	178	15916-16546	0425:16-0435:46
16	84	178	22062-22662	0607:42-0617:42
17	84	178	47219-47684	1306:59-1314:44
18	84	178	53300-53945	1448:20-1459:05
19	84	178	59440-59980	1630:40-1639:40
CU0112/ 1	84	179	14370-14985	0359:30-0409:45
2	84	179	20476-21106	0541:16-0551:46
3	84	179	51741-52371	1422:21-1432:51
4	84	179	57863-58448	1604:23-1614:08
5	84	180	12833-13403	0333:53-0343:23
6	84	180	18894-19539	0514:54-0525:39
7	84	180	50179-50794	1356:19-1406:34
8	84	180	56294-56909	1538:14-1548:29
9	84	181	11303-11828	0308:23-0317:08
10	84	181	17318-17978	0448:38-0459:38
11	84	181	23569-24064	0632:49-0641:04
12	84	181	48616-49201	1330:16-1340:01
13	84	181	54721-55351	1512:01-1522:31
14	84	182	15754-16399	0422:34-0433:19
15	84	182	21961-22501	0606:01-0615:01
16	84	182	47058-47598	1304:18-1313:18
17	84	182	53157-53802	1445:57-1456:42
18	84	183	14197-14842	0356:37-0407:22
19	84	183	20359-20944	0539:19-0549:04
CU0116/ 1	84	183	51588-52233	1419:48-1430:33
2	84	184	12646-13276	0330:46-0341:16
3	84	184	18769-19384	0512:49-0523:04
4	84	184	50025-50655	1353:45-1404:15
5	84	185	11103-11688	0305:03-0314:48
6	84	185	17187-17817	0446:27-0456:57
7	84	185	48462-49077	1327:42-1337:57
8	84	185	54586-55186	1509:46-1519:46
9	84	186	9570-10125	0239:30-0248:45
10	84	186	15608-16253	0420:08-0430:53
11	84	186	46902-47502	1301:42-1311:42
12	84	186	53013-53643	1443:33-1454:03
13	84	187	14041-14701	0354:01-0405:01
14	84	187	20265-20790	0537:45-0546:30
15	84	187	45345-45900	1235:45-1245:00
16	84	187	51446-52076	1417:26-1427:56
17	84	188	12480-13125	0328:00-0338:45

HILAT SUMMARY ROVER 87/04/15.

TAPE/FILE	YEAR	DAY	SEC1-SEC2	HHMM:SS-HHMM:SS
RU0001/ 1	84	31	7989- 8604	0213:09-0223:24
2	84	32	376- 916	0006:16-0015:16
3	84	60	78136-78751	2142:16-2152:31
4	84	61	76583-77183	2116:23-2126:23
5	84	65	76505-77000	2115:05-2123:20
6	84	66	27565-28000	0739:25-0746:40
7	84	66	74938-75433	2048:58-2057:13
8	84	67	25990-26440	0713:10-0720:40
9	84	67	73380-73860	2023:00-2031:00
10	84	68	71816-72296	1956:56-2004:56
11	84	70	74863-75298	2047:43-2054:58
12	84	71	25863-26343	0711:03-0719:03
13	84	71	73285-73735	2021:25-2028:55
14	84	72	71715-72165	1955:15-2002:45
15	84	75	19659-20049	0527:39-0534:09
16	84	75	73075-73570	2017:55-2026:10
17	84	76	71630-72050	1953:50-2000:50
18	84	77	22604-23084	0616:44-0624:44
19	84	77	70063-70483	1927:43-1934:43
20	84	78	21033-21558	0550:33-0559:18
21	84	79	66928-67333	1835:28-1842:13
RU0006/ 1	84	109	9274- 9724	0234:34-0242:04
2	84	118	48729-48879	1332:09-1334:39
3	84	120	4236- 4731	0110:36-0118:51
4	84	120	51661-51991	1421:01-1426:31
5	84	121	2677- 3157	0044:37-0052:37
6	84	122	1096- 1591	0018:16-0026:31
7	84	122	48527-48872	1328:47-1334:32
8	84	123	47020-47410	1303:40-1310:10
9	84	123	84518-84938	2328:38-2335:38
10	84	124	4226- 4601	0110:26-0116:41
11	84	124	45517-45667	1238:37-1241:07
12	84	124	51575-51875	1419:35-1424:35
13	84	125	2598- 3048	0043:18-0050:48
14	84	125	50011-50176	1353:31-1356:16
15	84	126	1041- 1491	0017:21-0024:51
16	84	126	86014-86194	2353:34-2356:34
17	84	127	46872-46872	1301:12-1301:12
18	84	127	84372-84702	2326:12-2331:42
19	84	128	45336-45336	1235:36-1235:36
20	84	128	82741-83206	2259:01-2306:46
21	84	129	81195-81645	2233:15-2240:45
22	84	130	884- 1304	0014:44-0021:44
23	84	130	85715-86135	2348:35-2355:35
24	84	131	46667-47102	1257:47-1305:02
25	84	132	82708-82993	2258:28-2303:13
26	84	133	43533-43983	1205:33-1213:03
27	84	133	81136-81436	2232:16-2237:16
28	84	134	41971-42376	1139:31-1146:16

1 HILAT SUMMARY ROVER 87/04/15.

TAPE/FILE	YEAR	DAY	SEC1-SEC2	HHMM:SS-HHMM:SS
RU0006/29	84	134	79662-79872	2207:42-2211:12
30	84	134	85732-85927	2348:52-2352:07
31	84	135	40399-40789	1113:19-1119:49
32	84	135	46466-46886	1254:26-1301:26
33	84	135	84140-84365	2322:20-2326:05
34	84	136	44903-45368	1228:23-1236:08
35	84	136	82563-82788	2256:03-2259:48
36	84	137	43341-43821	1202:21-1210:21
37	84	137	80976-81291	2229:36-2234:51
38	84	138	41885-42290	1138:05-1144:50
39	84	138	79408-79783	2203:28-2209:43
40	84	139	40318-40708	1111:58-1118:28
41	84	139	77827-78217	2137:07-2143:37
42	84	140	76285-76645	2111:25-2117:25
43	84	140	82398-82713	2253:18-2258:33
44	84	141	43244-43664	1200:44-1207:44
45	84	141	80866-81136	2227:46-2232:16
46	84	142	41675-42125	1134:35-1142:05
47	84	142	79221-79566	2200:21-2206:06
48	84	143	40104-40509	1108:24-1115:09
RU006A/ 1	84	109	9334- 9679	0235:34-0241:19
2	84	118	48790-48865	1333:10-1334:25
3	84	120	4308- 4713	0111:48-0118:33
4	84	120	51704-51944	1421:44-1425:44
5	84	121	2780- 3140	0046:20-0052:20
6	84	122	1227- 1572	0020:27-0026:12
7	84	123	47212-47362	1306:52-1309:22
8	84	124	4304- 4589	0111:44-0116:29
9	84	124	51637-51862	1420:37-1424:22
10	84	125	2770- 3040	0046:10-0050:40
11	84	126	1136- 1481	0018:56-0024:41
12	84	126	86118-86178	2355:18-2356:18
13	84	127	84481-84691	2328:01-2331:31
14	84	128	82822-83197	2300:22-2306:37
15	84	129	81241-81631	2234:01-2240:31
16	84	130	970- 1285	0016:10-0021:25
17	84	130	85759-86119	2349:19-2355:19
18	84	131	46710-47085	1258:30-1304:45
19	84	132	82738-82978	2258:58-2302:58
20	84	133	43586-43961	1206:26-1212:41
21	84	133	81165-81420	2232:45-2237:00
22	84	134	42023-42353	1140:23-1145:53
23	84	134	79736-79856	2208:56-2210:56
24	84	134	85773-85908	2349:33-2351:48
25	84	135	40451-40766	1114:11-1119:26
26	84	135	46515-46875	1255:15-1301:15
27	84	135	84178-84343	2322:58-2325:43
28	84	136	44935-45355	1228:55-1235:55
29	84	136	82605-82785	2256:45-2259:45

HILAT SUMMARY ROVER 87/04/15.

TAPE/FILE	YEAR	DAY	SEC1-SEC2	HHMM:SS-HHMM:SS
RU006A/30	84	137	43375-43810	1202:55-1210:10
31	84	137	81043-81268	2230:43-2234:28
32	84	138	41946-42276	1139:06-1144:36
33	84	138	79447-79762	2204:07-2209:22
34	84	139	40375-40690	1112:55-1118:10
35	84	139	77860-78205	2137:40-2143:25
36	84	140	76341-76626	2112:21-2117:06
37	84	140	82500-82695	2255:00-2258:15
38	84	141	43293-43653	1201:33-1207:33
39	84	141	80913-81123	2228:33-2232:03
40	84	142	41727-42102	1135:27-1141:42
41	84	142	79264-79564	2201:04-2206:04
42	84	143	40155-40500	1109:15-1115:00
RU0014/ 1	84	144	38542-38827	1042:22-1047:07
2	84	144	76092-76437	2108:12-2113:57
3	84	145	36981-37431	1016:21-1023:51
4	84	145	74626-74956	2043:46-2049:16
5	84	145	80881-81031	2228:01-2230:31
6	84	146	79200-79485	2200:00-2204:45
7	84	150	72709-73204	2011:49-2020:04
8	84	151	33756-34131	0922:36-0928:51
9	84	151	77591-77711	2133:11-2135:11
10	84	152	38249-38639	1037:29-1043:59
11	84	152	75930-76140	2105:30-2109:00
12	84	153	36683-37043	1011:23-1017:23
13	84	153	74311-74581	2038:31-2043:01
14	84	154	35113-35548	0945:13-0952:28
15	84	154	72693-73008	2011:33-2016:48
16	84	155	33581-33971	0919:41-0926:11
17	84	155	71152-71452	1945:52-1950:52
18	84	157	74033-74498	2033:53-2041:38
19	84	158	72560-72920	2009:20-2015:20
20	84	159	33459-33879	0917:39-0924:39
21	84	159	70990-71365	1943:10-1949:25
22	84	161	30332-30707	0825:32-0831:47
23	84	161	67878-68223	1851:18-1857:03
24	84	162	28772-29147	0759:32-0805:47
25	84	162	34843-35188	0940:43-0946:28
26	84	162	66256-66646	1824:16-1830:46
27	84	162	72423-72723	2007:03-2012:03
28	84	163	27213-27588	0733:33-0739:48
29	84	163	70850-71135	1940:50-1945:35
30	84	164	69284-69509	1914:44-1918:29
31	84	165	30125-30515	0822:05-0828:35
32	84	165	67717-68017	1848:37-1853:37
33	84	166	28552-29032	0755:52-0803:52
34	84	167	26991-27516	0729:51-0738:36
35	84	167	64457-64892	1754:17-1801:32
36	84	167	70618-70948	1936:58-1942:28

1 HILAT SUMMARY ROVER 87/04/15.

TAPE/FILE	YEAR	DAY	SEC1-SEC2	HHMM:SS-HHMM:SS
RU0014/37	84	168	25420-25900	0703:40-0711:40
38	84	168	31484-32009	0844:44-0853:29
39	84	168	69042-69387	1910:42-1916:27
40	84	169	29923-30418	0818:43-0826:58
41	84	169	67574-67814	1846:14-1850:14
42	84	170	28368-28893	0752:48-0801:33
43	84	171	26815-27340	0726:55-0735:40
44	84	171	64367-64802	1752:47-1800:02
45	84	172	25332-25782	0702:12-0709:42
46	84	173	61258-61663	1700:58-1707:43
47	84	173	67389-67734	1843:09-1848:54
48	84	174	22202-22622	0610:02-0617:02
49	84	174	28260-28725	0751:00-0758:45
50	84	174	65839-66154	1817:19-1822:34
51	84	175	26692-27172	0724:52-0732:52
52	84	177	23598-24018	0633:18-0640:18
53	84	177	61135-61450	1658:55-1704:10
54	84	178	21999-22449	0606:39-0614:09
55	84	178	59618-59888	1633:38-1638:08
56	84	178	65699-65939	1814:59-1818:59
RU014A/ 1	84	144	76143-76428	2109:03-2113:48
2	84	145	37018-37423	1016:58-1023:43
3	84	145	74749-74944	2045:49-2049:04
4	84	145	80929-81019	2228:49-2230:19
5	84	146	79320-79470	2202:00-2204:30
6	84	150	72965-73190	2016:05-2019:50
7	84	151	33816-34116	0923:36-0928:36
8	84	152	38297-38627	1038:17-1043:47
9	84	152	75954-76134	2105:54-2108:54
10	84	153	36730-37030	1012:10-1017:10
11	84	153	74381-74561	2039:41-2042:41
12	84	154	35159-35534	0945:59-0952:14
13	84	154	72753-72993	2012:33-2016:33
14	84	155	33664-33949	0921:04-0925:49
15	84	155	71219-71429	1946:59-1950:29
16	84	157	74119-74479	2035:19-2041:19
17	84	158	72633-72918	2010:33-2015:18
18	84	159	33528-33858	0918:48-0924:18
19	84	159	71040-71340	1944:00-1949:00
20	84	161	30393-30693	0826:33-0831:33
21	84	161	68045-68210	1854:05-1856:50
22	84	162	28834-29134	0800:34-0805:34
23	84	162	34871-35171	0941:11-0946:11
24	84	162	66379-66634	1826:19-1830:34
25	84	162	72495-72705	2008:15-2011:45
26	84	163	27273-27573	0734:33-0739:33
27	84	163	70985-71120	1943:05-1945:20
28	84	164	69395-69500	1916:35-1918:20
29	84	165	30176-30506	0822:56-0828:26

HILAT TAPE/FILE	SUMMARY YEAR	DAY	SONDRE SEC1-SEC2	REDO HHMM:SS-HHMM:SS
SUR001/ 1	83	249	85163-85748	2339:23-2349:08
2	83	250	4878- 5493	0121:18-0131:33
3	83	250	11017-11497	0303:37-0311:37
4	83	250	52624-53059	1437:04-1444:19
5	83	250	58733-59333	1618:53-1628:53
6	83	250	64961-65456	1802:41-1810:56
7	83	251	3323- 3938	0055:23-0105:38
8	83	251	9454- 9979	0237:34-0246:19
9	83	251	51083-51653	1411:23-1420:53
10	83	251	57165-57780	1552:45-1603:00
11	83	251	63378-63888	1736:18-1744:48
12	83	251	82042-82582	2247:22-2256:22
13	83	252	7886- 8441	0211:26-0220:41
14	83	252	49545-50085	1345:45-1354:45
15	83	252	61792-62332	1709:52-1718:52
16	83	252	80478-81003	2221:18-2230:03
17	83	253	202- 817	0003:22-0013:37
18	83	253	6326- 6911	0145:26-0155:11
19	83	253	48022-48517	1320:22-1328:37
20	83	253	54045-54660	1500:45-1511:00
21	83	253	60210-60645	1643:30-1650:45
22	83	253	78918-79413	2155:18-2203:33
23	83	253	85486-86086	2344:46-2354:46
24	83	254	46496-46961	1254:56-1302:41
25	83	254	52488-53103	1434:48-1445:03
26	83	254	58635-59220	1617:15-1627:00
27	83	254	83482-84082	2311:22-2321:22
28	83	255	3203- 3818	0053:23-0103:38
29	83	255	50944-51544	1409:04-1419:04
30	83	255	57063-57663	1551:03-1601:03
SUR007/ 1	83	255	81922-82507	2245:22-2255:07
2	83	256	1643- 2273	0027:23-0037:53
3	83	256	7777- 8287	0209:37-0218:07
4	83	256	49398-49983	1343:18-1353:03
5	83	256	55492-56092	1524:52-1534:52
6	83	256	61717-62227	1708:37-1717:07
7	83	256	80362-80917	2219:22-2228:37
8	83	257	83- 713	0001:23-0011:53
9	83	257	6213- 6753	0143:33-0152:33
10	83	257	47858-48413	1317:38-1326:53
11	83	257	53928-54543	1458:48-1509:03
12	83	257	78807-79347	2153:27-2202:27
13	83	258	4647- 5217	0117:27-0126:57
14	83	258	46327-46852	1252:07-1300:52
15	83	258	52368-52983	1432:48-1443:03
16	83	258	58549-59104	1615:49-1625:04
17	83	258	77243-77753	2127:23-2135:53
18	83	258	83367-83982	2309:27-2319:42
19	83	259	3087- 3687	0051:27-0101:27

1 HILAT SUMMARY SONDRE REDO 87/04/15.

HILAT TAPE/FILE	SUMMARY YEAR	DAY	SONDRE SEC1-SEC2	REDO HHMM:SS-HHMM:SS
SUR007/20	83	259	44797-45292	1226:37-1234:52
21	83	259	50813-51428	1406:53-1417:08
22	83	259	56967-57537	1549:27-1558:57
23	83	259	75675-76170	2101:15-2109:30
24	83	259	81807-82422	2243:27-2253:42
25	83	260	1526- 2141	0025:26-0035:41
26	83	260	49257-49872	1340:57-1351:12
27	83	260	55392-55992	1523:12-1533:12
28	83	260	80246-80846	2217:26-2227:26
29	83	261	47712-48312	1315:12-1325:12
30	83	261	53820-54420	1457:00-1507:00
31	83	261	60052-60547	1640:52-1649:07
32	83	261	78687-79272	2151:27-2201:12
33	83	261	84802-85432	2333:22-2343:52
34	83	262	4538- 5063	0115:38-0124:23
35	83	262	52248-52863	1430:48-1441:03
36	83	262	58462-58987	1614:22-1623:07
SUR013/ 1	83	262	77126-77681	2125:26-2134:41
2	83	262	83246-83876	2307:26-2317:56
3	83	263	2970- 3540	0049:30-0059:00
4	83	263	44632-45187	1223:52-1233:07
5	83	263	50688-51303	1404:48-1415:03
6	83	263	56884-57424	1548:04-1557:04
7	83	263	75567-76107	2059:27-2108:27
8	83	263	81686-82316	2241:26-2251:56
9	83	264	1411- 2011	0023:31-0033:31
10	83	264	43103-43613	1158:23-1206:53
11	83	264	49128-49743	1338:48-1349:03
12	83	264	55301-55871	1521:41-1531:11
13	83	264	80130-80745	2215:30-2225:45
14	83	265	41581-42046	1133:01-1140:46
15	83	265	47576-48191	1312:56-1323:11
SUR021/ 1	83	301	59138-59708	1625:38-1635:08
2	83	301	65257-65917	1807:37-1818:37
3	83	301	71388-71973	1949:48-1959:33
4	83	302	26637-27207	0723:57-0733:27
5	83	302	32688-33348	0904:48-0915:48
6	83	302	38876-39461	1047:56-1057:41
7	83	302	63701-64346	1741:41-1752:26
8	83	302	69825-70440	1923:45-1934:00
9	83	303	56010-56535	1533:30-1542:15
10	83	303	62142-62772	1715:42-1726:12
11	83	303	68261-68891	1857:41-1908:11
12	83	303	74412-74862	2040:12-2047:42
13	83	304	23587-24082	0633:07-0641:22
14	83	304	29577-30222	0812:57-0823:42
15	83	304	35715-36345	0955:15-1005:45
16	83	304	60577-61207	1649:37-1700:07

HILAT SUMMARY SONDRE REDO 87/04/15.

TAPE/FILE	YEAR	DAY	SEC1-SEC2	HHMM:SS-HHMM:SS
SUR021/17	83	304	66706-67351	1831:46-1842:31
18	83	305	28023-28653	0747:03-0757:33
19	83	305	34141-34786	0929:01-0939:46
20	83	305	65137-65782	1805:37-1816:22
21	83	306	26483-27098	0721:23-0731:38
22	83	306	32573-33038	0902:53-0910:38
23	83	306	63581-64226	1739:41-1750:26
24	83	307	31005-31665	0836:45-0847:45
25	83	307	62026-62671	1713:46-1724:31
26	83	307	68145-68745	1855:45-1905:45
27	83	308	29445-30105	0810:45-0821:45
28	83	308	60465-61095	1647:45-1658:15
29	83	308	66582-67017	1829:42-1836:57
SUR027/ 1	83	311	61901-62546	1711:41-1722:26
2	83	312	23253-23853	0627:33-0637:33
3	83	312	29328-29988	0808:48-0819:48
4	83	312	60341-60986	1645:41-1656:26
5	83	313	27766-28426	0742:46-0753:46
6	83	313	58785-59415	1619:45-1630:15
7	83	313	64906-65341	1801:46-1809:01
8	83	314	26206-26866	0716:46-0727:46
9	83	314	57222-57852	1553:42-1604:12
10	83	314	63346-63961	1735:46-1746:01
11	83	315	24652-25297	0650:52-0701:37
12	83	315	30796-31426	0833:16-0843:46
13	83	315	55658-56273	1527:38-1537:53
14	83	315	61785-62265	1709:45-1717:45
15	83	316	23103-23733	0625:03-0635:33
16	83	316	29223-29853	0807:03-0817:33
17	83	316	60221-60866	1643:41-1654:26
18	83	317	27652-28297	0740:52-0751:37
19	83	317	58666-59311	1617:46-1628:31
20	83	318	26089-26734	0714:49-0725:34
21	83	318	57102-57537	1551:42-1558:57
22	83	319	24525-25170	0648:45-0659:30
23	83	319	30709-31294	0831:49-0841:34
24	83	319	55541-56171	1525:41-1536:11
25	83	321	21416-22061	0556:56-0607:41
26	83	321	27548-28178	0739:08-0749:38
27	83	321	52425-53025	1433:45-1443:45
28	83	321	58545-59175	1615:45-1626:15
29	83	322	19871-20501	0531:11-0541:41
30	83	322	25977-26622	0712:57-0723:42
31	83	322	56981-57506	1549:41-1558:26
32	83	323	24409-25054	0646:49-0657:34
33	83	323	55421-56051	1523:41-1534:11
34	83	324	22845-23490	0620:45-0631:30
35	83	324	53862-54492	1457:42-1508:12
36	83	325	21289-21934	0554:49-0605:34

1 HILAT SUMMARY SONDRE REDO 87/04/15.

TAPE/FILE	YEAR	DAY	SEC1-SEC2	HHMM:SS-HHMM:SS
SUR033/ 1	83	325	46173-46683	1249:33-1258:03
2	83	325	52302-52917	1431:42-1441:57
3	83	325	58426-59041	1613:46-1624:01
4	83	326	13741-14236	0349:01-0357:16
5	83	326	19729-20374	0528:49-0539:34
6	83	326	25876-26491	0711:16-0721:31
7	83	326	32130-32625	0855:30-0903:45
8	83	326	44606-45086	1223:26-1231:26
9	83	326	50742-51342	1405:42-1415:42
10	83	326	56862-57477	1547:42-1557:57
11	83	326	63001-63466	1730:01-1737:46
12	83	327	18184-18814	0503:04-0513:34
13	83	327	24301-24931	0645:01-0655:31
14	83	327	30540-31050	0829:00-0837:30
15	83	327	43036-43501	1157:16-1205:01
16	83	327	49177-49762	1339:37-1349:22
17	83	327	55301-55931	1521:41-1532:11
18	83	327	61432-61942	1703:52-1712:22
19	83	328	16635-17250	0437:15-0447:30
20	83	328	22728-23373	0618:48-0629:33
21	83	328	28951-29491	0802:31-0811:31
22	83	328	47618-48173	1313:38-1322:53
23	83	328	53742-54372	1455:42-1506:12
24	83	328	59869-60409	1637:49-1646:49
25	83	329	15098-15683	0411:38-0421:23
26	83	329	21166-21811	0552:46-0603:31
27	83	329	27368-27923	0736:08-0745:23
28	83	329	46054-46594	1247:34-1256:34
29	83	329	52178-52808	1429:38-1440:08
30	83	329	58302-58887	1611:42-1621:27
SUR039/ 1	83	330	19602-20247	0526:42-0537:27
2	83	330	50618-51233	1403:38-1413:53
3	83	331	18045-18675	0500:45-0511:15
4	83	331	55177-55792	1519:37-1529:52
5	83	332	16492-17122	0434:52-0445:22
6	83	332	22624-23239	0617:04-0627:19
7	83	332	28876-29371	0801:16-0809:31
8	83	332	47497-48082	1311:37-1321:22
9	83	332	53614-54229	1453:34-1503:49
10	83	332	59753-60233	1635:53-1643:53
11	83	333	14943-15558	0409:03-0419:18
12	83	333	21052-21682	0550:52-0601:22
13	83	333	27285-27810	0734:45-0743:30
14	83	333	45937-46507	1245:37-1255:07
15	83	333	52054-52684	1427:34-1438:04
16	83	333	58185-58710	1609:45-1618:30
17	83	334	13403-13988	0343:23-0353:08
18	83	334	19481-20111	0524:41-0535:11

TAPE/FILE	YEAR	DAY	SEC1-SEC2	HHMM:SS-HHMM:SS
TUR001/ 1	83	316	35853-36453	0957:33-1007:33
2	83	316	41978-42623	1139:38-1150:23
3	83	316	48106-48691	1321:46-1331:31
4	83	317	9487-10147	0238:07-0249:07
5	83	317	15657-16272	0420:57-0431:12
6	83	317	46546-47146	1255:46-1305:46
7	83	318	1909- 2464	0031:49-0041:04
8	83	318	7932- 8577	0212:12-0222:57
9	83	318	14082-14712	0354:42-0405:12
10	83	318	20311-20851	0538:31-0547:31
11	83	318	32722-33292	0905:22-0914:52
12	83	318	38858-39488	1047:38-1058:08
13	83	318	44981-45596	1229:41-1239:56
14	83	319	378- 888	0006:18-0014:48
15	83	319	6379- 7024	0146:19-0157:04
16	83	319	12506-13136	0328:26-0338:56
17	83	319	18731-19256	0512:11-0520:56
18	83	319	37302-37932	1021:42-1032:12
19	83	319	43421-44051	1203:41-1214:11
20	83	320	4830- 5460	0120:30-0131:00
21	83	320	10938-11583	0302:18-0313:03
22	83	320	17145-17715	0445:45-0455:15
23	83	320	29588-30128	0813:08-0822:08
24	83	320	35737-36352	0955:37-1005:52
25	83	320	41862-42492	1137:42-1148:12
26	83	320	48003-48513	1320:03-1328:33
27	83	321	3286- 3901	0054:46-0105:01
28	83	321	9371-10016	0236:11-0246:56
29	83	321	15563-16148	0419:23-0429:08
30	83	321	28016-28541	0746:56-0755:41
31	83	321	34173-34773	0929:33-0939:33
TUR007/ 1	83	321	46425-46980	1253:45-1303:00
2	83	322	1743- 2328	0029:03-0038:48
3	83	322	7808- 8453	0210:08-0220:53
4	83	322	13984-14584	0353:04-0403:04
5	83	322	32614-33199	0903:34-0913:19
6	83	322	38742-39372	1045:42-1056:12
7	83	323	6251- 6896	0144:11-0154:56
8	83	323	37178-37808	1019:38-1030:08
9	83	324	4691- 5336	0118:11-0128:56
10	83	324	40046-40676	1107:26-1117:56
11	83	325	40178-40808	1109:38-1120:08
12	83	325	46308-46818	1251:48-1300:18
13	83	326	1598- 2213	0026:38-0036:53
14	83	326	7695- 8340	0208:15-0219:00
15	83	326	13897-14467	0351:37-0401:07
16	83	326	26340-26865	0719:00-0727:45
17	83	326	32502-33102	0901:42-0911:42
18	83	326	44742-45282	1225:42-1234:42

TAPE/FILE	YEAR	DAY	SEC1-SEC2	HHMM:SS-HHMM:SS
TUR007/19	83	327	57- 657	0000:57-0010:57
20	83	327	6128- 6773	0142:08-0152:53
21	83	327	30934-31519	0835:34-0845:19
22	83	327	37061-37691	1017:41-1028:11
23	83	327	43182-43752	1159:42-1209:12
24	83	327	49347-49647	1342:27-1347:27
25	83	327	84916-85486	2335:16-2344:46
26	83	328	4571- 5216	0116:11-0126:56
27	83	328	10741-11341	0259:01-0309:01
28	83	328	29366-29936	0809:26-0818:56
29	83	328	35501-36131	0951:41-1002:11
30	83	328	41617-42202	1133:37-1143:22
31	83	328	83385-83925	2309:45-2318:45
32	83	329	3011- 3656	0050:11-0100:56
33	83	329	9158- 9773	0232:38-0242:53
34	83	329	15394-15919	0416:34-0425:19
35	83	329	27802-28357	0743:22-0752:37
TUR013/ 1	83	329	33934-34564	0925:34-0936:04
2	83	329	40062-40662	1107:42-1117:42
3	83	330	1458- 2088	0024:18-0034:48
4	83	330	7590- 8205	0206:30-0216:45
5	83	330	13808-14348	0350:08-0359:08
6	83	330	26236-26776	0717:16-0726:16
7	83	330	32378-32993	0859:38-0909:53
8	83	330	38497-39112	1041:37-1051:52
9	83	330	44632-45112	1223:52-1231:52
10	83	330	86310-86925	2358:30-2408:45
11	83	331	6019- 6649	0140:19-0150:49
12	83	331	12221-12776	0323:41-0332:56
13	83	331	24672-25197	0651:12-0659:57
14	83	331	84762-85362	2332:42-2342:42
15	83	332	4452- 5082	0114:12-0124:42
16	83	332	10642-11212	0257:22-0306:52
17	83	332	23096-23606	0624:56-0633:26
18	83	332	29251-29836	0807:31-0817:16
19	83	332	35377-36007	0949:37-1000:07
20	83	332	41501-42041	1131:41-1140:41
21	83	332	83221-83806	2307:01-2316:46
22	83	333	2888- 3533	0048:08-0058:53
23	83	333	9063- 9648	0231:03-0240:48
24	83	333	15304-15814	0415:04-0423:34
25	83	333	27686-28256	0741:26-0750:56
26	83	333	33818-34448	0923:38-0934:08
27	83	333	39938-40508	1105:38-1115:08
28	83	333	81690-82245	2241:30-2250:45
29	83	334	1327- 1957	0022:07-0032:37
30	83	334	7485- 8085	0204:45-0214:45
31	83	334	13718-14243	0348:38-0357:23
32	83	334	26122-26677	0715:22-0724:37

TAPE/FILE	YEAR	DAY	SEC1-SEC2	HHMM:SS-HHMM:SS
TUR013/33	83	334	32253-32868	0857:33-0907:48
34	83	334	80156-80681	2215:56-2224:41
35	83	334	86172-86802	2356:12-2406:42
36	83	335	30694-31309	0831:34-0841:49
37	83	335	36817-37417	1013:37-1023:37
TUR019/ 1	83	335	84615-85245	2330:15-2340:45
2	83	336	4336- 4966	0112:16-0122:46
3	83	336	10552-11092	0255:52-0304:52
4	83	336	83071-83686	2304:31-2314:46
5	83	337	2768- 3398	0046:08-0056:38
6	83	337	8967- 9522	0229:27-0238:42
7	83	337	27566-28151	0739:26-0749:11
8	83	337	33690-34305	0921:30-0931:45
9	83	337	81525-82110	2238:45-2248:30
10	83	338	7388- 7958	0203:08-0212:38
11	83	338	26003-26573	0713:23-0722:53
12	83	338	32131-32746	0855:31-0905:46
13	83	338	38253-38808	1037:33-1046:48
14	83	338	79991-80546	2213:11-2222:26
15	83	338	86041-86671	2354:01-2404:31
16	83	339	5809- 6394	0136:49-0146:34
17	83	339	24439-24994	0647:19-0656:34
18	83	339	30566-31181	0829:26-0839:41
19	83	339	36691-37261	1011:31-1021:01
20	83	339	78457-78982	2147:37-2156:22
21	83	339	84484-85114	2328:04-2338:34
22	83	340	4231- 4831	0110:31-0120:31
23	83	340	22872-23412	0621:12-0630:12
24	83	340	29007-29622	0803:27-0813:42
25	83	340	35126-35726	0945:26-0955:26
26	83	340	82927-83542	2302:07-2312:22
27	83	341	2658- 3273	0044:18-0054:33
28	83	341	8880- 9405	0228:00-0236:45
29	83	341	21303-21828	0555:03-0603:48
30	83	341	27443-28043	0737:23-0747:23
31	83	341	33562-34162	0919:22-0929:22
TUR025/ 1	83	341	81379-81994	2236:19-2246:34
2	83	342	1092- 1707	0018:12-0028:27
3	83	342	7297- 7837	0201:37-0210:37
4	83	342	19740-20250	0529:00-0537:30
5	83	342	25883-26483	0711:23-0721:23
6	83	342	32006-32621	0853:26-0903:41
7	83	342	79833-80433	2210:33-2220:33
8	83	342	85920-86550	2352:00-2402:30
9	83	343	5716- 6271	0135:16-0144:31
10	83	343	24319-24904	0645:19-0655:04
11	83	343	30443-31058	0827:23-0837:38
12	83	343	36571-37111	1009:31-1018:31

TAPE/FILE	YEAR	DAY	SEC1-SEC2	HHMM:SS-HHMM:SS
TUR025/13	83	343	78292-78862	2144:52-2154:22
14	83	343	84357-84987	2325:57-2336:27
15	83	344	4132- 4702	0108:52-0118:22
16	83	344	22758-23328	0619:18-0628:48
17	83	344	28882-29497	0801:22-0811:37
18	83	344	35011-35566	0943:31-0952:46
19	83	344	76756-77296	2119:16-2128:16
20	83	344	82797-83427	2259:57-2310:27
21	83	345	2557- 3142	0042:37-0052:22
22	83	345	21191-21746	0553:11-0602:26
23	83	345	27322-27937	0735:22-0745:37
24	83	345	33443-34028	0917:23-0927:08
25	83	345	81240-81855	2234:00-2244:15
26	83	346	982- 1582	0016:22-0026:22
27	83	346	25758-26358	0709:18-0719:18
28	83	346	31883-32483	0851:23-0901:23
29	83	346	79687-80302	2208:07-2218:22
30	83	346	85808-86423	2350:08-2400:23
31	83	347	5625- 6150	0133:45-0142:30
32	83	347	18052-18577	0500:52-0509:37
33	83	347	24195-24795	0643:15-0653:15
34	83	347	30316-30931	0825:16-0835:31
TUR031/ 1	83	347	78143-78743	2142:23-2152:23
2	83	348	28755-29370	0759:15-0809:30
3	83	348	34886-35396	0941:26-0949:56
4	83	348	76593-77163	2116:33-2126:03
5	83	348	82672-83287	2257:52-2308:07
6	83	349	2456- 3026	0040:56-0050:26
7	83	349	21071-21641	0551:11-0600:41
8	83	349	27196-27811	0733:16-0743:31
9	83	349	33318-33858	0915:18-0924:18
10	83	349	75056-75611	2050:56-2100:11
11	83	349	81113-81728	2231:53-2242:08
12	83	350	878- 1448	0014:38-0024:08
13	83	350	19504-20059	0525:04-0534:19
14	83	350	25632-26247	0707:12-0717:27
15	83	350	31755-32325	0849:15-0858:45
16	83	350	73523-74048	2025:23-2034:08
17	83	350	79552-80167	2205:52-2216:07
18	83	350	85702-86287	2348:22-2358:07
19	83	351	17937-18477	0458:57-0507:57
20	83	351	24071-24671	0641:11-0651:11
21	83	351	30191-30776	0823:11-0832:56
22	83	351	77996-78611	2139:56-2150:11
23	83	351	84128-84728	2322:08-2332:08
24	83	352	3949- 4474	0105:49-0114:34
25	83	352	16372-16897	0432:52-0441:37
26	83	352	22507-23107	0615:07-0625:07
27	83	352	28628-29228	0757:08-0807:08

APPENDIX B

HILAT SUMMARY TAPE FORMAT

HILAT

SUMMARY TAPE FORMAT

TIME/GEOMETRY/MAGNETIC FIELD SUMMARY DATA
330 16-bit word record (note 1)

(one per 15-second summary block)

	Parameter	Number of 16-bit Words
- Universal time	Year	1
	Day	1
	Hour	1
	Minute	1
	Second	1
	Millisecond	1
- Station	Geodetic latitude--degree +N	2
	Longitude--degree +E	2
	Geodetic altitude--km	2
	NORAD ephemeris elements, line 1	35
	NORAD ephemeris elements, line 2	35
	Azimuth angle to satellite--degree	2
	Elevation angle to satellite--degree	2
	Range to satellite--km	2
	Local earth radius--km	2
	(spares)	48
- Satellite	Geodetic latitude--degree +N	2
	Longitude--degree +E	2
	Geodetic altitude--km	2
	Geocentric position X--km (note 2)	2
	Geocentric position Y--km (note 2)	2
	Geocentric position Z--km (note 2)	2
	Geocentric velocity X--km/s (note 2)	2
	Geocentric velocity Y--km/s (note 2)	2
	Geocentric velocity Z--km/s (note 2)	2
	Orbital attitude pitch--degree (note 3)	2
	Orbital attitude yaw--degree (note 3)	2
	Orbital attitude roll-degree (note 3)	2
	Invariant magnetic latitude, APL eccentric dipole--degree	2
	Magnetic local time, APL eccentric dipole--seconds	2
	Magnetic dip, IGRF80--degree	2
	Magnetic declination, IGRF80--degree	2
	Magnetic strength north, IGRF80--mG	2
	Magnetic strength east, IGRF80-mG	2
	Magnetic strength vertical, IGRF80--mG	2

HILAT

SUMMARY TAPE FORMAT (Cont.)

	Parameter	Number of 16-bit Words
- Satellite	Solar right ascension--degree	2
	Solar decliantion--degree	2
	Solar zenith angle--degree	2
	Sun-shade angle--degree	2
	Invariant magnetic latitude, Gustafsson model--degree	2
	Magnetic longitude, Gustafsson model--degree	2
	(spares)	4
- Magnetic field	Geodetic latitude (350 km)--degree +N	2
line through	Longitude (350 km)--degree +E	2
satellite	Geodetic altitude (350 km)--km	2
(IGRF80)	Solar zenith angle (350 km)--degree	2
	Sun-shade angle (350 km)--degree	2
	Geodetic latitude (100 km)--degree +N	2
	Longitude (100 km)--degree +E	2
	Geodetic altitude (100 km)--km	2
	Solar zenith angle (100 km)--degree	2
	Sun-shade angle (100 km)--degree	2
	Geodetic latitude (surface)--degree +N	2
	Longitude (surface)--degree +E	2
	Geodetic altitude (surface)--km	2
	Solar zenith angle (surface)--degree	2
	Sun-shade angle (surface)-degree	2
	(spares)	4
- F-region	Geodetic latitude--degree +N	2
penetration	Longitude--degree +E	2
(350 km)	Geodetic altitude--km	2
	Invariant magnetic latitude, APL eccentric dipole--degree	2
	Magnetic local time, APL eccentric dipole--seconds	2
	Magnetic dip, IGRF80--degree	2
	Magnetic declination, IGRF80--degree	2
	Magnetic strength north, IGRF80--mG	2
	Magnetic strength east, IGRF80--mG	2
	Magnetic strength vertical, IGRF80--mG	2
	Propagation zenith angle--degree	2
	Propagation magnetic azimuth--degree	2
	Off-magnetic field propagation angle, IGRF80--degree	2
	Off-magnetic meridian propagation angle, IGRF80--degree 2	
	Off-magnetic L-shell propagation angle, IGRF80--degree	2

HILAT

SUMMARY TAPE FORMAT (Cont.)

	Parameter	Number of 16-bit Words
- F-region penetration (350 km)	Reduced propagation range--km	2
	Magnetic penetration velocity X--km/s (note 4)	2
	Magnetic penetration velocity Y--km/s (note 4)	2
	Magnetic penetration velocity Z--km/s (note 4)	2
	(spares)	6
- E-region penetration (100 km)	Geodetic latitude--degree +N	2
	Longitude--degree +E	2
	Geodetic altitude--km	2
	Invariant magnetic latitude, APL eccentric dipole--degree	2
	Magnetic local time, APL eccentric dipole--seconds	2
	Magnetic dip, IGRF80--degree 2	
	Magnetic declination, IGRF80--degree	2
	Magnetic strength north, IGRF80--mG	2
	Magnetic strength east, IGRF80--mG	2
	Magnetic strength vertical, IGRF80--mG	2
	Propagation zenith angle--degree	2
	Propagation magnetic azimuth--degree	2
	Off-magnetic field propagation angle, IGRF80--degree	2
	Off-magnetic meridian propagation angle, IGRF80--degree	2
	Off-magnetic L-shell propagation angle, IGRF80--degree	2
	Reduced propagation range--km	2
	Magnetic penetration velocity X--km/s (note 4)	2
	Magnetic penetration velocity Y--km/s (note 4)	2
	Magnetic penetration velocity Z--km/s (note 4)	2
	(spares)	6
- Magnetic field line thourgh F-region penetration	Geodetic latitude (100 km)--degree +N	2
	Longitude (100 km)--degre +E	2
	Geodetic altitude (100 km)--km	2
	(spares)	2

HILAT

SUMMARY TAPE FORMAT (Cont.)

	Parameter	Number of 16-bit Words
- Processing tag	Year	1
	Day	1
	Hour	1
	Minute	1
	(spares)	2

note 1 - one word parameters are 16-bit integers, two word parameters are HP 32-bit real words, and the NORAD elements are ASCII coded FORTRAN F10.5 format

note 2 - geocentric coordinates are right-hand earth-centered inertial with X through the line of Aries and Z through the north pole

note 3 - attitude procesing/error flags are as follows:

- -999 no attitude solution attempted
- -998 telemetry frame error
- -997 all sensors dark
- -996 solar sensor word unpack error
- -995 model-data magnetic field magnitude error
- -994 model-data magnetic field/sunline angle error
- -993 orthogonalization error
- -992 orthogonalization error
- -991 orthogonalization error
- -990 miscellaneous error

note 4 - penetration magnetic coordinates are right-hand, X magnetic north and Z nadir

<u>HILAT</u>

TM SUMMARY DATA

7830 16-bit words, split into two 3915 word records (note 1)

(one pair, two records, per 15-second summary block)

	Parameter		Number of 16-bit words
- Span	Start time of 1st TM frame--second (note 2)		2
	End time of 31st TM frame--second (note 2)		2
	(spares)		6
- Unpacked TM	(sequence repeated 31 times)		7812
	Frame count (note 3)	(2)	
	Overrange bit and sync status (note 4)	(1)	
	SDF timer	(1)	
	NSD/SAD	(1)	
	Beacon housekeeping	(1)	
	Magnetometer	(31)	
	Particle detector	(97)	
	AIM	(62)	
	Drift meter	(56)	
- Ancillary data	(spares)		8

---

note 1 - all parameters are 16-bit integer words, except as noted

note 2 - times are with respect to the time/geometry/magnetic field point in Table 3

note 3 - frame count is in 32-bit integer format

note 4 - overrange bit and sync status is as follows:

0 frame sync, no overrange
1 frame sync, overrange
2 frame sync error, no overrange
3 frame sync error, overrange
4 no frame sync, no overrange
5 no frame sync, overrange
6 replacement for missing frame

HILAT

SCINTILLATION SUMMARY DATA

990 16-bit word record (note 1)

(one per 15-second summary block)

	Parameter	Number of 16-bit words
- Span	Start time of data--second (note 2)	2
	End time of data--second (note 2)	2
	(spares)	6
- 137 MHz	Mean signal level--db	2
	Intensity scintillation index S4	2
	Intensity fade period--second	2
	Intensity decorrelation time--second	2
	Standard deviation of phase--rad	2
	Intensity power spectral density function decimated in log frequency--db S4 units sq/Hz	100
	Phase power spectral density function decimated in log frequency--db rad sq/Hz	100
	Frequencies of above power spectral density samples--Hz	100
- 413 MHz *antenna 1*	Mean signal level--db	2
	Intensity scintillation index S4	2
	Intensity fade period--second	2
	Intensity decorrelation time-second	2
	Standard deviation of phase--rad	2
	Intensity power spectral density function decimated in log frequency--db S4 units sq/Hz	100
	Phase power spectral density function decimated in log frequency--db rad sq/Hz	100
	Frequencies of above power spectral density samples--Hz	100
- 1239 MHz	Mean signal level--db	2
	Intensity scintillation index S4	2
	Intensity fade period--second	2
	Intensity decorrelation time--second	2
	Intensity power spectral density function decimated in log frequency--db S4 unts sq/Hz	100
	Frequencies of above power spectral density samples--Hz	100

SCINTILLATION SUMMARY DATA (Cont.)

	Parameter	Number of 16-bit words
- 390 MHz	Mean signal level--db	2
	Intensity scintillation index S4	2
	Intensity fade period--second	2
	(spare)	2
	Standard deviation of phase--rad	2
	(spares)	10
- 413 MHz antenna 2	Mean signal level--db	2
	Intensity scintillation index S4	2
	Intensity fade period--second	2
	Intensity decorrelation time--second	2
	Standard deviation of phase--rad	2
	(spares)	10
- 413 MHz antenna 3	Mean signal level--db	2
	Intensity scintillation index S4	2
	Intensity fade period--second	2
	Intensity decorrelation time--second	2
	Standard deviation of phase--rad	2
	(spares)	10
- 435 MHz	Mean signal level--db	2
	Intensity scintillation index S4	2
	Intensity fade period--second	2
	(spare)	2
	Standard deviation of phase--rad	2
	(spares)	10
- TEC	Total electron content along propagation raypath, three equispaced samples--el/m sq	6
- Irregularity anisotropy and drift	Axial ratio of receiver plane correlation surface	2
	Geographic azimuth of receiver plane correlation surface--degree	2
	Receiver plane correlation surface velocity, magnetic north--km/s	2
	Receiver plane correlation surface velocity, magnetic east--km/s	2

SCINTILLATION SUMMARY DATA (Cont.)

	Parameter	Number of 16-bit words
- Angular deviation	Standard deviation of phase difference, antennas 1,2--rad	2
	Standard deviation of phase difference, antennas 1,3--rad	2
	Standard deviation of phase difference, antennas 2,3--rad	2
- Ancillary data	(spares)	52

---

note 1 - all parameters are HP 32-bit real words; items not calculated are dummy filled with -999

note 2 - times are with respect to the time/geometry/magnetic field point and will always be -15. and +15. seconds

HILAT

SCIENCE SUMMARY DATA

1875 16-bit word record (note 1)

(one per 15-second summary block)

	Parameter	Number of 16-bit Words
- Span	Start time of data--second (note 2)	2
	End time of data--second (note 2)	2
	(spares)	6
- Vector Magnetometer	X-axis data--counts	30
	Y-axis data--counts	30
	Z-axis data--counts	30
	X-axis calibration offset (note 3)	2
	Y-axis calibration offset (note 3)	2
	Z-axis calibration offset (note 3)	2
	calibration matrix (3x3)	18
	B-x deviation, 30 s detrend--nT	20
	B-y devation, 30 s detrend--nT	20
	B-x current density estimate--A/m*m	20
	B-y curent density estimate--A/m*m	20
	B-x power spectal density function decimated in log frequency--db nT sq/Hz	40
	B-y power spectral density function decimated in log frequency--db nT sq/Hz	40
	Frequencies of above power spectral density samples--Hz	40
	B magnitude, rms model-data, fit--nT (note 4)	2
	B-sunline angle, rms model-data fit--deg (note 4)	2
	(spares)	12

HILAT

SCIENCE SUMMARY DATA (Cont.)

	Parameter	Number of 16-bit Words
- Particle Detector	Instrument mode	2
	(spare)	2
	Scaled data, mode dependent--counts (note 5)	960
	mode 1: vertical sensor, 0.25 s average channel 1, 60 samples through channel 8, 60 samples	
	mode 2: vertical sensor, 0.5 s average channel 1, 30 samples through channel 16, 30 samples	
	mode 3: all sensors, 1.5 s average channel 1, vertical sensor, 10 samples through channel 16, vertical sensor, 10 samples channel 1, 45 degree sensor, 10 samples through channel 16, 45 degree sensor, 10 samples channel 1, nadir sensor, 10 samples through channel 16, nadir sensor, 10 samples	
	Log integral number flux,energy <630 eV, vertical sensor--e/cm/cm-s-sr	20
	Log integral energy flux, energy <630 eV, vertical sensor--keV/cm/cm-s-sr	20
	Log integral number fluxenergy >1 keV, vertical sensor--e/cm/cm-s-sr	20
	Log integral energy flux, energy >1 keV, vertical sensor--keV/cm/cm-s-sr	20
	Integral energy flux energy <630 eV, power spectral density function decimated in log frequency --db flux units sq/Hz	40

HILAT

SCIENCE SUMMARY DATA (Cont.)

	Parameter	Number of 16-bit Words
- Particle Detector	Integral energy flux energy >1 keV, power spectral density function decimated in log frequency --db flux units sq/Hz	40
	Frequencies of above power spectral density samples--Hz	40
	(spares)	10
- IDM/RPA	Ion density, IDM--cm^{-3}	20
	Ion temperature--degrees K	20
	Ion density, RPA--cm^{-3}	20
	(spares)	20
	Ram velocity--km/s	20
	Crosstrack velocity--km/s	20
	Vertical velocity--km/s	20
	(spares)	20
	Ion density power spectral density function decimated in log frequency--db e/cm^{-3} sq/Hz	16
	Cross-track velocity power spectral density function decimated in log frequency--db km/s sq/Hz	40
	Frequencies of above power spectral density samples--Hz	40
	(spares)	40
- Nadir Photometers	3914 A intensity--rayleighs 20	
	6300 A intensity--rayleighs 20	
- Spacecraft Attitude	Rotation matrix (3x3), vehicle to geographic (note 4)	18
	B-x rms model-data fit--nT (note 4)	2
	B-y rms model-data fit--nT (note 4)	2
	B-z rms model-data fit--nT (note 4)	2

HILAT

SCIENCE SUMMARY DATA (Cont.)

note 1 - all parameters are HP 32-bit real words, except for magentometer counts, which are 16-bit integers

note 2 - times are with respect to the time/geometry/magnetic field point and will correspond to those in the telemetry records

note 3 - nominal (February 1984) values are used if the offsets are not optimized, e.g. the pass is sunlit for less than two minutes

note 4 - dummy values (-999) are used if the pass is sunlit for les than two minutes

note 5 - the particle detector channel energies are as follows:

channel 1	.020 keV
channel 2	.032 keV
channel 3	.054 keV
channel 4	.088 keV
channel 5	.144 keV
channel 6	.235 keV
channel 7	.385 keV
channel 8	.632 keV
channel 9	.632 keV
channel 10	1.035 keV
channel 11	1.700 keV
channel 12	2.780 keV
channel 13	4.550 keV
channel 14	7.450 keV
channel 15	12.200 keV
channel 16	20.000 keV

APPENDIX C

HILAT DATA BASE FORMATS

HILAT J SENSOR/THERMAL PLASMA EXPERIMENT/SCINTILLATION DATA BASE

Data Base Tapes 9 Track
6250 bpi
Labeled
W-I

General Structure:

Each tape has multiple passes. Each file has data from one station pass. Each file has two preface records (preceding the measurement data). There is an EOF after each station pass and a double EOF following the data for each experiment.

Structure is as follows:

Multiple passes of J Sensor (J/SENSOR Program)

Double EOF

Multiple passes of IDM density (TAPE2)

Double EOF

Multiple passes of IDM drift velocity (TAPE3)

Double EOF

Multiple passes of Electron Sensor "current" (TAPE20)

Double EOF

Multiple passes of Electron Sensor F1,F2,F3,F4 (TAPE22)

Double EOF

Multiple passes of RPA data (TAPE21)

Double EOF

Multiple passes of Scintillation Data (SCINT. Program)

Double EOF

Files may be accessed by using a combination of COPYBF & COPYBR.

Skip all files for "Experiments" using COPYBF. Skip files within an experiment type by using COPYBR.

For example, to position tape at beginning of 4th file of RPA data.

```
COPYBF,LFN,XX,5.
COPYBF,LFN,XX,3.
```

HILAT

Preface Record 1

Word	Description	Format
1	Year	F
2	Day of year	F
3	Geodetic latitude of station	F
4	Longitude of station	F
5-15	Orbital elements used in ephemeris computations for this pass	F

HILAT

Preface Record 2

The time spacing between 'frames' is 15 seconds. There are 'N' groups of 45 words in this record (since the maximum pass duration is less than 20 minutes, this record should never exceed 3600 words). The first word in this record is N (ineger), the number of groups of 45 words. The format of each group in the record repeated N-1 times is as follows:

Word No.	Description	Format
1	UT (seconds)	F
2	Geodetic latitude (deg)	F
3	Longitude (+E)	F
4	Geodetic altitude (km)	F
5	Geocentric position X (km)	F
6	Geocentric position Y (km)	F
7	Geocentric position Z (km)	F
8	Geocentric velocity $\dot{X}$ (km/s)	F
9	Geocentric velocity $\dot{Y}$ (km/s)	F
10	Geocentric velocity $\dot{Z}$ (km/s)	F
11	Orbital attitude pitch	F
12	Orbital attitude yaw	F
13	Orbital attitude roll	F
14	Invariant magnetic latitude	F
15	Magnetic local time (seconds)	F
16	Magnetic dip (degrees)	F
17	Magnetic declination (degrees)	F
18	Magnetic strength - North (NT)	F
19	Magnetic strength - East (NT)	F
20	Magnetic strength - Vertical (NT)	F
21	Solar right ascension (degrees)	F
22	Solar declination (degrees)	F
23	Solar zenith angle	F
24	Sun-shade indicator	F
25	CGM latitude (deg)	F
26	CGM longitude (deg	F

HILAT

Preface Record 2 (Cont.)

Word No.	Description	Format
27	CGM local time (hrs)	F
28	MF line thru satellite - Geod. lat. (350 km)	F
29	MF line thru satellite - Geod. long. (350 km)	F
30	MF line thru satellite - Geod. alt. (350 km)	F
31	MF line thru satellite - Geod. SZA (350 km)	F
32	MF line thru satellite - S/S indicator (350 km)	F
33	MF line thru satellite - Geod. lat. (100 km)	F
34	MF line thru satellite - Geod. long. (100 km)	F
35	MF line thru satellite - Geod. alt. (100 km)	F
36	MF line thru satellite - Geod. SZA (100 km)	F
37	MF line thru satellite - Geod. S/S (100 km)	F
38	MF line thru satellite - Geod. lat. (surface)	F
39	MF line thru satellite - Geod. long. (surface)	F
40	MF line thru satellite - Geod. alt. (surface)	F
41	Inv. Mag. Lat. of F region Pen (350 km)	F
42	Magnetic LT (hrs) {0-24}	F
43	Vacant	F
44	Vacant	F
45	Vacant	F

HILAT

J/Sensor Data Base

There will be one file per pass. Each file will have a header record followed by a series of data records.

Header Record

0.1	Word count (8)	(I)
1	Year	F
2	Day	F
3	Latitude of station (*)	F
4	Longitude of station (*)	F
5	Instrument mode (at beginning of pass (1., 2. or 3.)	F
6	Start time of pass (UT seconds)	F
7	Run date of file creation	A
8	Run time of file creation	A

(*) Indicates information obtained from SRI tape

(**) From AFGL/SUNY ephemeris

J/Sensor Data Base (Cont.)

Data Records (One second per record)

0.1	Word count (112)		(I)
1	Mode indicator (1., 2. or 3.)		F
2	UT (sec)		
3	Alt (km)	From AFGL/SUNY ephemeris	
4	Longitude		
5	Geodetic latitude		
6	Local time (sec)		
7	Geomagnetic latitude		
8	Magnetic LT (sec)		
9	CGM latitude		
10	CGM longitude		
11	CGM LT (hours + Frac of hours)		
12	Invariant latitude		
13	Mag field Bx	From $IGRF_{80}$	
14	Mag field By		
15	Mag field Bz		
16	Pitch	From summary tape(*)	
17	Yaw		
18	Roll		
19	X	Spacecraft position and velocity(*)	
20	Y		
21	Z		
22	X		
23	Y		
24	Z		
25-35	Spares		
36	HV monitor (V) from most recent TLM readout		
37	LV monitor (V) from most recent TLM readout		

J/Sensor Data Base (Cont.)

Word	Description	Format
38	Temp (°C) (V) from most recent TLM readout	F
	Particle counts words are the computed counts from the TLM data (i.e. counts $= 2^E(AM+32)-33$) packed into 15 bit words. Frames missing due to TLM dropout will have 1 filled 15 bit words (77777_8). There are 192 15 bit words (48 60 bit words)	
39-86	Packed counts data stored as follows: (Z = Zenith detector; F = Forty deg; N = Nadir) - subscript indicates channel	I

In mode 1:

$Z_1, Z_2, Z_3, \ldots, Z_8$ repeated 24 times

In mode 2:

$Z_1, Z_2, \ldots, Z_{16}$ repeated 12 times

In mode 3:

$Z_1, Z_2, \ldots, Z_{16}$, $Z_1, \ldots, Z_{16}$, $Z_1, \ldots, Z_{16}$, $Z_1, \ldots, Z_{16}$
$F_1, F_2, \ldots, F_{16}$, $F_1, \ldots, F_{16}$, $F_1, \ldots, F_{16}$, $F_1, \ldots, F_{16}$
$N_1, N_2, \ldots, N_{16}$, $N_1, \ldots, N_{16}$, $N_1, \ldots, N_{16}$, $N_1, \ldots, N_{16}$

(i.e. 4 groups of 16 zenith spectra, followed by 4 groups of forty degree detector spectra followed, by 4 groups of Nadir detector spectra.)

Word	Description	Format
87-102	The next group of words will be 31 words per telemetry frame (~1/2 sec) from the magnetometer (total of 62 words) packed into 15 bit words. (The 30 LSBS of word 102 will be vacant)	I
103	ID word from even block	I
104-110	Spares	I

J/Sensor Data Base (Cont.)

Word	Description	Format
111	Time of telemetry frame for which Line No. = 6.	F
112	Packed photometer data (56 bits of information -right adjusted - the 6 photometer words plus housekeeping word 41 which contains photometer on/off discretes.)	I

HILAT

IDM DATA BASE (Density)

(5 words/record)

Word	Description	Format
1	Year (last 2 digits of 19xx)	I
2	Day of year	I
3	UT (seconds)	F
4	IDM frame counter	I
5	Ion density (cm^3)	F

Dummy fill value is -999999.

IDM DATA BASE (Drift Velocity)

(20 words/record)

Word	Description	Format
1	Year (last 2 digits of 19xx)	I
2	Day (day of year)	I
3	UT (seconds)	F
4	IDM frame counter	I
5-20	16 velocity values [order is a function of frame counter]	F

Dummy fill value is -999999.

HILAT

ELECTRON SENSOR DATA BASE (Current)

(20 words/record)

Word	Description	Format
1	Year (last 2 digits of 19xx)	I
2	Day (day of year)	I
3	UT (seconds)	F
4	Electron sensor frame counter	I
5-20	16 values of electron sensor tlm. volts	F

Dummy fill value is -999999.

ELECTRON SENSOR DATA BASE (F_1, F_2, F_3, F_4)

(8 words/record)

Word	Description	Format
1	Year (last 2 digits of 19xx	I
2	Day (day of year)	I
3	UT (seconds)	F
4	Electron sensor frame counter	I
5	F_1 (volts)	F
6	F_2 (Volts)	F
7	F_3 (volts)	F
8	F_4 (volts)	F

Dummy fill value is -999999.

HILAT

RPA DATA BASE

(35 words/record)

Word	Description	Format
1	Year (last 2 digits of 19xx)	I
2	Day (day of year)	I
3	UT (seconds)	F
4	RPA frame counter	I
5	Velocity (km/s)	F
6	Sensor potential	F
7	Vehicle potential	F
8	Satlelite potential w.r.t. instrument bias	F
9	Iion temperature (deg K)	F
10	Ion density 1 (cm^3)	F
11	Mass 1 (kg)	F
12	Ion density 2 (cm^3)	F
13	Mass 2 (kg)	F
14	Drift velocity (m/s)	F
15	Mass in AMU of light component (H+=1, HE+=4)	I
16	Total ion density (cm^3)	F
17	Est. variance of the linear ion current	F
18	Est. variance of the logarithmic ion current	F
19-35	FA(I,K) = Array containing final results (I=1,11 and K=1,3)	F

FA(I,1)	Contains values of the "Best Solution" with respect to the minimum of the linear variance, where only one parameter-position of the second characteristic slope is allowed to vary.
FA(I,K)	Where K=2,3, contain values of the limiting solutions to the left/right of the "Best" position of the second characteristic slope
FA(1,K)	Est. var. of the lin. ion current
FA(2,K)	Est. var. of the log. ion current
FA(3,K)	VHALF(2) position of the second char. slope
FA(4,K)	Slope at VHALF(2)

HILAT

RPA DATA BASE (Cont.)

(35 words/record)

Word	Description	Format
19-35	FA(5,K) Ion current at VHALF(2)	
	FA(6,K) Ion density 1 (cm^3)	
	FA(7,K) Ion density 2 (cm^3)	
	FA(8,K) Ion temp. (deg K)	
	FA(9,K) Drift velocity normal to RPA apert. (m/s)	
	FA(10,K) Satellite potential w.r.t. instrument bias (volts)	
	FA(11,K) Mode, 1=1 ion case, 2=2 ion case	

For no solution

Dummy fill value is 9.9×10^9 or 9.9×10^3

HILAT

SCINTILLATION STATISTICS DATA BASE

Word No.	Desc.
1	Year (I) e.g. 83,84,85,
2	Day of year (I)
3	Station code (I) (1=Sondre; 2=Tromso, 3=Churchill; 4=Rover)
4	UT (seconds)

Words 5-69 from TIME/GEOM/MF Record

Word No.	Desc.	
5	- station	Geodetic latitude - degree +N
6		Longitude - degree +E
7		Geodetic altitude - km
8		Azimuth angle to satellite - degree
9		Elevation angle to satellite - degree
10	- satellite	Geodetic latitude - degree +N
11		Longitude - degree +E
12		Geodetic altitude - km
13		Orbital attitude pitch - degree
14		Orbital attitude yaw - degree
15		Orbital attitude roll - degree
16		Invariant magnetic latitude, APL eccentric dipole - degree
17		Magnetic local time, APL eccentric dipole - 0 seconds
18		Magnetic dip, IGRF80 - degree
19		Magnetic declination, $IGRF_{80}$ - degree
20		Solar right ascension - degree
21		Solar declination - degree
22		Solar zenith angle - degree

HILAT

SCINTILLATION STATISTICS DATA BASE (Cont.)

Words 5-69 from TIME/GEOM/MF Record

Word No.	Desc.	
23	- magnetic field line	Geodetic latitude (350 km) - degree +N
24	through	Longitude (350 km) - degree +E
25	satellite	Geodetic altitude (350 km) - km
26	(IGRF80)	Geodetic latitude (100 km) - degree +N
27		Longitude (100 km) - degree +E
28		Geodetic altitude (100 km) - km
29	- F-region	Geodetic latitude - degree +N
30	penetration	Longitude - degree +E
31	(350 km)	Geodetic altitude -- km
32		Invariant magnetic latitude, APL eccentric dipole - degree
33		Magnetic local time, APL eccentric dipole - seconds
34		Magnetic dip, $IGRF_{80}$ - degree
35		Magnetic decliaton, $IGRF_{80}$ - degree
36		Magnetic strength north, $IGRF_{80}$ - mg
37		Magnetic strength east, $IGRF_{80}$ - mg
38		Magnetic strength vertical, $IGRF_{80}$ - mg
39		Propagation zenith angle -- degree
40		Propagation magnetic azimuth - degree
41		Off-magnetic field propagation angle, $IGRF_{80}$ - degree
42		Off-magnetic meridian propagation angle, $IGRF_{80}$ - degree
43		Off-magnetic L-shell propagation angle, $IGRF_{80}$ - degree
44		Reduced propagation range - km
45		Magnetic penetration velocity X - km/s
46		Magnetic penetration velocity Y - k/S

HILAT

SCINTILLATION STATISTICS DATA BASE (Cont.)

Words 5-69 from TIME/GEOM/MF Record

Word No.	Desc.	
47		Magnetic penetration velocity Z - km/s
48	- E-region	Geodetic latitude - degree +N
49	penetration	Longitude - degree + E
50	(100 km)	Geodetic altitude - km
51		Invariant magnetic latitude, APL eccentric dipole - degree
52		Magnetic local time, APL eccentric dipole - seconds
53		Magnetic dip, $IGRF_{80}$ - degree
54		Magnetic declination, $IGRF_{80}$ - degree
55		Magnetic strength north, $IGRF_{80}$ - mg
56		Magnetic strength east, $IGRF_{80}$ - mg
57		Magnetic strength vertical, $IGRF_{80}$ - mg
58		Propagation zenith angle - degree
59		Propagation magnetic azimuth - degree
60		Off-magnetic field propagation angle, $IGRF_{80}$ - degree
61		Off-magnetic meridian propagation angle, $IGRF_{80}$ - degree
62		Off-magnetic L-shell propagation angle, $IGRF_{80}$ - degree
63		Reduced propagation range - km
64		Magnetic penetration velocity X - km/s
65		Magnetic penetration velocity Y - km/s
66		Magnetic penetration velocity Z - km/s

HILAT

SCINTILLATION STATISTICS DATA BASE (Cont.)

Words 5-69 from TIME/GEOM/MF Record

Word No.	Desc.	
67	- Magnetic field line through	Geodetic latitude (100 km) - degree +N
68	F-region penetration	Longitude (100 km) - degree +E
69		Geodetic altitude (100 km) - km

Words 70-84 from Scintillation Records

Word No.	Desc.	
70	-137 MHz	Mean signal level - db
71		Intensity scintillation index S4
72		Intensity fade period - second
73		Intensity decorrelation time - second
74		Standard deviation of phase - rad
75	- 413 MHz	Mean signal level - db
76	antenna 1	Intensity scintillation index S4
77		Intensity fade period - second
78		Intensity decorrelation time - second
79		Standard deviation of phase - rad
80	- 1239 MHz	Mean signal level - db
81		Intensity scintillation index S4
82-84	- TEC	Total electron content along propagation ray path, three equispaced samples -- e /m sq

HILAT

SCINTILLATION SSTATISTICS DATA BASE (Cont.)

Words 85-204 from SCI/SUM Records

Word No.	Desc.	
85-94	- Particle Detector	Log integral number flux, energy <630 ev, vertical sensor -- e/cm/cm-s-sr, ten samples
95-104		Log integral energy flux, energy <630 ev, vertical sensor -- kev/cm/cm-s-sr, ten samples
105-114		Log integral number flux, energy >1 kev, vertical sensor -- e/cm/cm-s-sr, ten samples
115-124		Log integral energy flux, energy >1 kev, vertical sensor -- kev/cm/cm-s-sr, ten samples
125-134	- IDM/RPA	Ion density, IDM -- cm-3, ten samples
135-144		Ram velocity -- km/s, ten samples
145-154		Crosstrack velocity -- km/s, ten samples
155-164		Vertical velocity -- km/s, ten samples
165-184		Frequencies of cross track velocity power spectral density samples -- Hz, twenty samples
185-194	- Nadir photometers	3914 A intensity-rayleights, 10 samples
195-204		6300 A intensity - rayleighs, 10 samples

As done for previous 'scintillation data base'*

Word No.	Desc.		
205	Slope (p)	intensity	137 MHz
206	RMS		
207	TI (1 Hz value)		

SCINTILLATION STATISTICS DATA BASE (Cont.)

Word No.	Desc.		
208	Slope 1 (P1)	phase	137 MHz
209	RMS 1	phase	137 MHz
210	Slope 2 (P2)	phase	137 MHz
211	RMS 2	phase	137 MHz
212	TP (1 Hz value)	phase	137 MHz
213	Slope (P)	intensity	413 MHz
214	RMS	intensity	413 MHz
215	TI (1 Hz value)	intensity	413 MHz
216	Slope 1 (P1)	phase	413 MHz
217	RMS 1	phase	413 MHz
218	Slope 2 (P2)	phase	413 MHz
219	RMS 2	phase	413 MHz
220	TP (1 Hz value)	phase	413 MHz

Fits and integrations to science summary data parameters

221	Slope/10 (P)
222	1 Hz value (T) from By fit 1
223	RMS value (RMS)
224	Area (A)
225-228	As above for By fit 2
229-232	As above for integral energy flux <630 eV fit 1
233-236	As above for integral energy flux <630 eV, fit 2
237-240	As above for integral energy flux >1 kev, fit 1
241-244	As above for integral energy flux >1 kev, fit 2
245-248	As above for cross track velocity, fit 1
249-252	As above for cross track velocity, fit 1
253-256	As above for ion density, 1 fit
257	$\dot{x}$
258	$\dot{y}$ satellite velocity (km/sec)
259	$\dot{z}$
260	Range to satellite (km)
261	J sensor instrument mode
262-270	Vacant

HILAT

SCINTILLATION DATA BASE STATISTICS FILE FORMAT

(24 Parameters)

```
Dimension STMEAN(12,12),ST10P(12,12),ST50P(12,12),
     ST90P(12,12),STCNTS(12,12)
DO 10 KP=1,2
DO 1 IREAD=1,24
 1   READ(1)STMEAN,ST10P,ST50P,ST90P,STCNTS
     READ(1) NFILES,NR1,NR2,NR3,NR4,NR5,NR6,NR7,NR8,ISTNCD,
           IDBEG,IDEND,NR9,NR10
10   Continue
```

Five arrays are read for each of 24 parameters:

STMEAN is mean value
ST10P is 10th percentile value
ST50P is 50th percentile value
ST90P is 90th percentile value
STCNTS is number of occurrences in each bin

Lastly, a preface record where NFILES = total number of files (i.e. revs) in data set.

NR1 - Input data recs used after elevation, Inv. Lat. & K_p exclusion for parameters 19 & 20

NR8 - Input data recs used after elevation, Inv. Lat. & K_p exclusion for parameters 1 to 18

NR2 - Recs used after exclusion for scintillation freq's all zero

NR3 - Recs remaining after S_4 exclusion

NR4 - Recs remaining after σ_ϕ exclusion

NR5 - Recs remaining after 10 ion density values outside range 10^3 to 10^6

NR6 - Recs remaining after avg. energy exclusion for Mode $\neq 2$ or 3

NR7 - Recs excluded for avg. energy denominator $<10^3$

ISTNCD - Station code (1=Sondre; 2=Tromso; 3=Churchill)

IDBEG - Start day of data set (e.g. 83317)

IDEND - End day of data set (e.g. 84031)

NR9 - Recs excluded from low energy of flux for denominator <1000

NR10 - Recs excluded from high energy & flux for denominator <1000

This sequence is done twice for 2 K_p values: $K_p \leq 3.5$ and $K_p > 3.5$.

For all arrays, the values are stored as 12x12, with rows 1→12 being Magnetic Local Time, starting at 23 hours, incrementing in 2 hour bins. Columns 1→12 are the Invariant Latitude bins, starting at 50°, incrementing in 2.5° bins.

In the case of 1 hour magnetic local time bins, for all arrays, the values are stored as 24x12, with rows 1-24 being magnetic local time, starting at 22.5 hours, incrementing in 1 hour bins. Columns 1-12 are the invariant latitude bins, starting at 50°, incrementing in 2.5° bins.

HILAT SCINTILLATION DATA BASE STATISTICS FILE FORMAT (Cont.)
(24 Parameters)

The names of the 24 parameters are:

No.	Name
1	Mean signal, 137 MHz
2	Scintillation index intensity, 137 MHz
3	Fade period intensity, 137 MHz
4	Decorrelation time intensity, 137 MHz
5	Phase std. deviation, 137 MHz
6	Mean signal, 413 MHz
7	Scintillation index intensity, 413 MHz
8	Fade period intensity, 413 MHz
9	Decorrelation time intensity, 413 MHz
10	Phase std. deviation, 413 MHz
11	Mean signal 1239 MHz
12	TEC
13	Phase slope 1, 137 MHz
14	Phase slope 2, 137 MHz
15	Phase T_p, 137 MHz
16	Phase slope 1, 413 MHz
17	Phase slope 2, 413 MHz
18	Phase T_p, 413 MHz
19	Average ion density
20	Average energy-particle detector
21	Average energy - particle detector (low)
22	Energy flux - particle detector (low)
23	Average energy - particle detector (high)
24	Energy flux - particle detector (high)

HILAT SCIENCE SUMMARY DATA BASE STATISTICS FILE FORMAT

(27 Parameters)

```
Dimension  STMEAN(12,12), ST10P(12,12), ST50P(12,12),
           ST90P(12,12),
           STCNTS(12,12)

DO 10 KP=1,2

DO  1 IREAD=1,27

 1    READ(1) STMEAN,ST10P,ST50P,ST90P,STCNTS
      READ(1) NFILES,(NR(I),I=1,10),ISTNCD,IDDBEG,IDEND

10    Continue
```

Five arrays are read for each of 27 parameters:

STMEAN is mean value
ST10P is 10th percentile value
ST50P is 50th percentile value
ST90P is 90th percentile value
STCNTS is number of occurrences in each bin

Lastly, a preface record where:

NFILES	= Total number of files (i.e. revs) in data set	
(NR(I),I=1,10) = 1		total number of input data base records read.
	2-10)	records used for each set of 3 parameters, respectively.
ISTNCD	= Station code (1=Sondre; 2=Tromso; 3=Churchill)	
IDBEG	= Start day of data set (e.g. 84032)	
IDEND	= End day of data set (e.g. 84121)	

[illegible] is done twice for 2 K_p values: K_p ≤ 3.5 and [illegible]

[illegible] arrays, the values are stored as 12x12, with rows 1- [illegible] magnetic local time, starting at 23 hours, [illegible] in 2 hour bins. Columns 1-12 are the invariant [illegible] starting at 50°, incrementing in 2.5° bins.

[illegible] 1 hour magnetic local time bins, for all [illegible] values are stored as 24x12, with rows 1-24 [illegible] time, starting at 22.5 hours, incrementing [illegible] Columns 1-12 are the invariant latitude bins, [illegible], incrementing in 2.5° bins.

HILAT SCIENCE SUMMARY DATA BASE STATISTICS FILE FORMAT
(Cont.)

(27 Parameters)

The names of the 27 parameters are:

No.	Name
1	By slope 1
2	By T1
3	By area 1
4	By slope 2
5	By T2
6	By area 2
7	Loen slope 1
8	Loen T1
9	Loen area 1
10	Loen slope 2
11	Loen T2
12	Loen area 2
13	Hien slope 1
14	Hien T1
15	Hien area 1
16	Hien slope 2
17	Hien T2
18	Hien area 2
19	CRVEL slope 1
20	CRVEL T1
21	CRVEL area 1
22	CRVEL slope 2
23	CRVEL T2
24	CRVEL area 2
25	Ion den slope 1
26	Ion den T1
27	Ion den area 10

HILAT

PHOTOMETER DATA BASE

Record 1: Input pref record 1 from input (summary tape)

Record 2: Input ephemeris rec from input (summary tape)

Record 3: 100 words as follows:

Word No.	
1-4	Not used
5	UT (secs)
6	Geod. altitude
7	Geod. longitude
8	not used
9	Geod. latitude
10	not used
11	CGM latitude
12	CGM longitude
13	CGM local time
14	Solar zenith angle
15	Sun-shade indicator
16	Geocentric position - X
17	Geocentric position - Y
18	Geocentric position - Z
19	Geocentric velocity - X
20	Geocentric velocity - Y
21	Geocentric velocity - Z
22	Orbital attitude pitch
23	Orbital attitude yaw
24	Orbital attitude roll
25	Inv. Mag. latitude
26	Mag. local time
27	Mag. strength - North
28	Mag. strength - East
29	Mag. strength - Vertical
30-40	Not used
41-87	Magnetometer (6 frames)
88-95	Photometer & Housekeeping words
95	ID
96-100	Not used

HILAT

AIM Data Base

There will be one file per station pass. Each file will have a 2 header records followed by a series of data records.

Header Record 1

1	Year	F
2	Day	F
3	Latitude of station	F
4	Longitude of station	F
5	AIM mode at beginning of pass 1. = Imaging; 2. = Spectrometer; 3. = photometer	F
6	Start time of pass - UT seconds	F
7	Run date of file creation	A
8	Run time of file creation	A
9	Wavelength (if in imaging or photometer mode - if spect mode value = -1.)	F

Header Record 2

Ephemeris data REC (45xN)
Same as Preface REC 2 under Input, part VIII

Data Records

Each data record is constructed from 6 telemetry frames (~3 seconds). The record is structured such that the first AIM word in a data record is the first word of a mode cycle. Data from the imager is packed into 15 bit words. Telemetry words missing due to dropout will be 1 filled (i.e. 77777_8).

Format Word No.	Description		
1	Mode indicator (1. = Imaging; 2. = Spectrometer; 3. = photometer)		
2	Code (0. = Normal; 1. = Electrical Test; 2. = Optical Test)		
3	Status (0. = Normal; 1. = Same words filled due to TLM dropout)		
4	Wavelength (meaningful only in imaging & photometer mode		
5	UT (sec)		
6	Altitude (km)		
7	Longitude (+E)		
8	blank		
9	Geodetic latitude		
10	blank		
11	Corrected Geomagnetic latitude		
12	Corrected Geomagnetic longitude		
13	Corrected Geomagnetic local time (sec)		
14	Solar zenith angle		
15	Sun/shade indicator (-1. = shade; +1. = sun)		from Preface
16	X		Rec 2-Ephemeris
17	Y	position vector	
18	Z		
19	$\dot{X}$		
20	$\dot{Y}$		
21	$\dot{Z}$		
22	Pitch		
23	Yaw		
24	Roll		
25	Invariant mag. lat.		
26	Magnetic LT		
27	B_N		
28	B_E		
29	B_V		

HILAT AIM Data Base (Cont.)

Format Word No.	Description
30	Sun sensor indicated (0 = all s/s off; 1 = photo A on; 2 = photo B on 3 = A & B on; 4 = AIM on; 5 = A & AIM on; 6 = B & AIM on; 7 = all on)
31	Line counter
32	Prescalar flag (0. = no prescalar; 1. = prescalar)
33-40	Vacant
41-87	Magnetometer data (31 words per telemetry frame x 6 frames are packed into 15 bit words. This requires 46.5 60-bit words; the 30 LSBS of word 47 are vacant magnetometer data
88-171	Pixel data (336 15 bit words = 84 CDC words)
172-180	The remaining words (15 bits/word) in the record are in the sequence below and result in 9 CDC words: Fixed photometer data (6 15-bit wds) λ position (1)Nadir point (1) Spectrometer Status words (6) AIM housekeeping (16) ID words from scan (6)
181-190	Vacant (spares)

APPENDIX D

AIRS DATA BASE FORMAT

HILAT

AIRS Data Base Format

The AIRS data base is created with one station pass per file. The data base is archived on 9-Track digital tape at a density of 6250cpi. Each tape contains the data from at least one Summary Tape.

Data base files will consist of 2 preface (or header) records followed by a series of AIRS data base records.

PREFACE RECORD 1

This record consists of 15 words.

Word No.	Description
1	Year (F)
2	Day of year (F)
3	Latitude of station (F)
4	Longitude of station (F)
5	AIRS operating mode at beginning of the pass (F) 1.=Imaging, 2.=Spectrometer, 3.=Photometer
6	Start time of pass -UT seconds (F)
7	Run date of file creation (A)
8	Run time of file creation (A)
9	Wavelength of Det 1 (-1. if in spectrometer mode)
10	Wavelength of Det 2 (" " ")
11	Wavelength of Det 3 (" " ")
12	Wavelength of Det 4 (" " ")
13-15	Vacant

PREFACE RECORD 2

This record contains satellite ephemeris, magnetic and attitude data extracted from the Summary Tape. Data stored in this record is written in block form to allow for interpolation of parameters not stored on data base records. The time spacing between blocks is 15 seconds (as is on the Summary Tape). There are 45 parameters contained in each block. A leading integer word is provided to indicate the number of blocks in the record (since record size will vary depending on the time duration of the pass). No pass should exceed 30 minutes and thus the record will not be larger than 5401 words. All words are 60 bit floating point.

AIRS Data Base Format (Cont.)

A READ statement of the form

```
READ(x) N, ((D(I,J), I=1,45), J=1,N)
```

should be used to input the entire record.

The word order of the 45 words in each block is as follows:

Word No.	Description
1	UT - seconds
2	Geodetic latitude - deg
3	Longitude (+E) - deg
4	Geodetic altitude - km
5	Geocentric position X - km
6	" " Y - km
7	" " Z - km
8	Geocentric velocity X - km/sec
9	" " Y - km/sec
10	" " Z - km/sec
11	Pitch - deg
12	Yaw - deg
13	Roll - deg
14	Invariant mag. latitude (APL eccentric dipole)- deg
15	Magnetic local time (APL eccentric dipole) -sec
16	Magnetic dip - deg (IGRF 85)
17	Magnetic declination - deg (IGRF 85)
18	Magnetic strength North - mG (IGRF 85)
19	" " East - mG (IGRF 85)
20	" " Vertical - mG (IGRF 85)
21	Solar right ascension - deg
22	Solar declination - deg
23	Solar zenith angle - deg

AIRS Data Base Format (Cont.)

Word No.	Description
24	Sun/shade angle - deg
25	Invariant mag. lat (Gustafsson model) - deg
26	Magnetic longitude (Gustaffson model) - deg
27	Magnetic local time (Gustafsson model) -hrs

Words 28 through 40 contain information on the magnetic field line through the satellite projected to 350 km, 100km, and the earth's surface.

28	350km geodetic latitude - deg
29	" longitude - deg
30	" altitude - km
31	" solar zenith angle
32	" Sun/shade angle - deg
33	100km geodetic latitude - deg
34	" longitude - deg
35	" altitude - km
36	" solar zenith angle - deg
37	" Sun/shade angle - deg
38	Surface geodetic latitude - deg
39	" longitude - deg
40	" altitude - km
41	Inv. Mag Lat of F-region penetration - deg
42	Magnetic local time of F-region penetration - hrs
43	Code word (0. = no science summary record on Summary Tape; 1. = science summary record on tape)
44	Vacant
45	Vacant

AIRS Data Base Format (Cont.)

AIRS DATA BASE RECORDS

There are 419 words per record.

Word No.	Description
1	Mode indicator (1.=Imaging; 2.=Spectrometer;
3	3.=Photometer)
2	Test status (1.=Normal; 2.=Dark shutter; 3.=Optical test; 4.=Extended dark shutter)
3	TLM status (0.=normal; 1.=some words 1's filled)
4	Detector 1 wavelength (-1. if spectrometer mode)
5	Detector 2 wavelength (" " " ")
6	Detector 3 wavelength (" " " ")
7	Detector 4 wavelength (" " " ")
8	UT - sec
9	Altitude - km
10	Longitude - deg
11	Vacant
12	Geodetic latitude - deg
13	Vacant
14	Invariant mag. lat (Gustafsson model) - deg
15	Magnetic longitude (Gustafsson model) - deg
16	Magnetic local time (Gustafsson model) -hrs
17	Solar zenith angle
18	Sun/shade angle - deg
19	X position - km
20	Y position - km
21	Z position - km
22	X velocity - km/sec
23	Y velocity - km/sec
24	Z velocity - km/sec
25	Pitch - deg
26	Yaw - deg
27	Roll - deg

AIRS Data Base Format (Cont.)

Word No.	Description
28	Invariant mag. latitude (APL eccentric dipole)-deg
29	Magnetic local time (APL eccentric dipole)-sec
30	B-North - mG
31	B-East - mG
32	B-Vertical - mG
33	SDF frame count
34	AIRS line counter
35-40	Vacant
41-87	Magnetometer data stored in 15 bit words. (There are 31 15 bit magnetometer words for each SDF frame. There are 10 words for the X,Y and Z magnetometers and one flag word. The groups of 10 words represent one B-field measurement and 9 delta B values. Six such frames (accumulated over the AIRS scan) will be stored. The 30 LSB's of word 87 will be vacant.
88-169	Detector 1 pixel data
170-251	Detector 2 pixel data
252-333	Detector 3 pixel data
334-415	Detector 4 pixel data (The telemetry counts for the 326 pixel words from each detector will be decompressed and stored in 15 bit words. This results in 82 CDC words per detector. The 30 LBS's of the 82nd word for each detector will be vacant.)
416-419	AIRS status and housekeeping words. (The 16 telemetry words (206-221) from line count 6 will be retained in counts and stored into 15 bit words.

APPENDIX E

ACCELEROMETER DATA BASE TAPES AND FORMATS

ACCELEROMETER

DATA BASE TAPES AND FORMATS

[illegible] DENSITY DATA BASE TAPES (100 [illegible]) FILTER)
NINE TRACK 1600 BPI NOSBE MULTI-FILE LABELLED TAPES (W-I)

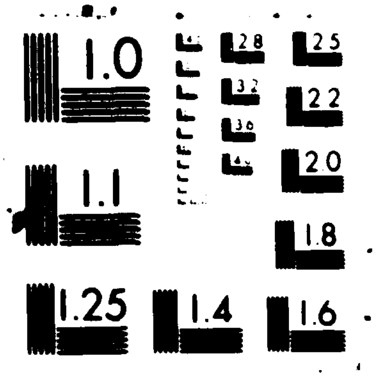
[illegible]	[illegible]	CC2101	CC2663	CC2918	CC0963	CC4674	CC0969	CC1850
[illegible]	[illegible]	142	143	144	152	154	158	185
[illegible]	[illegible]	[illegible]	169	183	153	184	159	-
[illegible]	[illegible]	[illegible]	[illegible]	220	195	244	160	156
[illegible]	[illegible]	[illegible]	228	[illegible]	-	194	162	226
[illegible]	141	227	-	164	199	235	163	147
[illegible]	[illegible]	151	[illegible]	234	200	191	165	198
[illegible]	[illegible]	216		161	157		166	
[illegible]	[illegible]				217		167	
[illegible]	149				218		249	
[illegible]					196			

[illegible]	[illegible]3406	CC3407	CC1184	CC1180	CC3415	CC1185	CC3426	CC3427
[illegible]	182	240	253	264	263	297	-	325
[illegible]	192	241	260	265	180	295	303	326
[illegible]	193	246	272	266	-	308	304	327
4	[illegible]	247	273	278	274	311	305	328
	214	248	276	279	275	313	306	329
[illegible]	-	250	282	280	287	321	307	330
[illegible]	219	-	288		301	324	310	331
[illegible]	251	252	296		302		312	215

AD-A182 599 ANALYSIS SYSTEMS FOR AIR FORCE MISSIONS(U) BOSTON COLL CHESTNUT HILL MA SPACE DATA ANALYSIS LAB D E DELOREY ET AL 28 FEB 87 BC-SDAL-87-1 2/2

UNCLASSIFIED AFGL-TR-87-0100 F19628-83-C-0100 F/G 14/2 NL

END
8-87
DTIC


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8

DATA BASE TAPES AND FORMATS (Cont.)

NPS 1982 DENSITY DATA BASE TAPES (20/15 FILTER)
NINE TRACK 6250 BPI UNLABELLED (W-I)
(USE SKIPF OR COPYBF)

FILE	CC3257	CC1158	CC3288	CC3322	CC1397	CC4071	CC1508
1	-	141	149	161	185	217	220
2	134	142	151	166	186	226	227
3	135	143	152	167	187	228	235
4	136	144	153	168	188	229	236
5	137	145	154	169	189	230	237
6	138	147	157	180	191	231	248
7	139	148	158	184	192	232	249
8	140	155	159	190	193	233	250
9	146	156	160	199	194	234	251
10		162		200	195		258
11		163		201	196		268
12		164		202	197		269
13		165		214	198		270
14		174		215	206		283
15		175		216	207		284
16		176			208		285
17					218		290
18					219		291
19							305
20							306
21							307

FILE	CC4072	CC4472	CC4473	CC4498	CC4501	CC4503
1	235	259	271	280	301	313
2	240	260	272	281	302	321
3	241	261	273	282	303	322
4	244	262	274	287	304	323
5	245	263	275	288	308	324
6	246	264	276	295	309	325
7	247	265	277	296	310	326
8	252	266	278	-	311	327
9	253	267	279		312	328
10						329
11						330
12						331

ACCELEROMETER

DATA BASE TAPES AND FORMATS (Cont.)

NP6 1983-1984 DENSITY DATA BASE TAPES
NINE TRACK 6250 BPI UNLABELLED (W-I)
(USE SKIPF OR COPYBF)

FILE	CC4221	CC3206	CC4294	CC3209	CC3228	CC3232	CC4327	CC4353
1	201	214	265	274	332	1	37	58
2	202	215	266	275	333	2	38	59
3	203	216	273	282	334	3	39	60
4	204	228	276	283	338	4	40	61
5	205	229	277	284	339	5	42	62
6	206	230	278	294	340	6	43	63
7	207	234	285	300	341	7	44	64
8	213	235	289	304	342	8	45	65
9	217	236	290	309	343	18	46	66
10	218	237	291	315	344	-	47	67
11	219	238	292	316	345	-	48	68
12	220	239	293	317	346	29	49	69
13	221	248	301	318	347	30	50	70
14	222	249	302	319	354	31	51	71
15	247	250	303	320	355	32	52	72
16	257	258	310	321	363	34	53	73
17	261	259	311	326	364	35	54	74
18	262	260	312		365	36	55	
19	263	267	313				56	
20	264	268	314				57	
21		269	327					

ACCELEROMETER

DATA BASE TAPES AND FORMATS (Cont.)

S85-1 1984 DENSITY DATA BASE TAPES
NINE TRACK 6250 BPI UNLABELLED (W-I)
(USE SKIPF OR COPYBF)

TAPE/FILE	DAYS	TAPE/FILE	DAYS	TAPE/FILE	DAYS
CC0290/1	210,211	CC0887/1	239,240	CC0517/1	259,260
/2	212,213	/2	241,242	/2	261
/3	214,215	/3	241,242	/3	261,262
/4	213	/4	243,244	/4	263,264
/5	214	/5	245	/5	265
/6	215,216	/6	245,246	/6	265,266
/7	213	/7	247,248	/7	267,268
/8	214	/8	246,247	/8	269,270
/9	216,217	/9	250,251	/9	219,220
/10	218,219	/10	252	/10	221
		/11	247,248	/11	221,222
CC0828/1	229,230	/12	249,250	/12	222,223
/2	231	/13	251,252	/13	223,224
/3	231,232	/14	253,254	/14	225,226
/4	233	/15	254,255	/15	225,226
/5	233,234	/16	256,257	/16	227
/6	235	/17	256,257	/17	226,227
/7	235,236	/18	258,259	/18	228,229
/8	237				
/9	237,238			CC0833/1	269,270
/10	239			/2	271,272
/11	201			/3	272,273
				/4	274,275
				/5	276
				/6	275,276
				/7	277
				/8	280,281
				/9	282
				/10	277,278
				/11	279,280
				/12	271
				/13	275
				/14	281,282
				/15	283

ACCELEROMETER

RAW/FILTER TAPE FORMAT

HEADER	DESCRIPTION	FORMAT
0.1	word count (40)	I
0.2	group count (1)	I
1	satellite ID	A
2	year of data (since 1900) (YY)	F
3	Julian date of data (YYDDD)	F
4	vacant	F
5	order of temperature fit polynomial	F
6	A0 (temperature fit polynomial coefficients)	F
7	A1	F
8	A2	F
9	A3	F
10	A4	F
11	number of temperature points used in fit	F
12	start time of temperature fit	F
13	stop time of temperature fit	F
14	number of missing data frames	F
15	frame increment (time between xyz samples)	F
16	date of test DMA (raw data) run (MM/DD/YY)	A
17	Julian date of raw data run (YYDDD)	R
18	start time of accelerometer data	F
19	stop time of accelerometer data	F
20	vacant	F
21	start time of filtered data	F
22	stop time of filtered data	F
23	Julian date of filter run (YYDDD)	R
24	filter length	F
25	F3 X-axis filter parameters	F
26	F4 "	F
27	F3 Y-axis filter parameters	F
28	F4 "	F
29	F3 Z-axis filter parameters	F
30	F4 "	F
31	flag for treatment of missing points	F
32	number of missing points	F
33	flag for treatment of wild points	F
34	number of X-axis wild points	F
35	number of Y-axis wild points	F
36	number of Z-axis wild points	F
37-40	vacant	F

ACCELEROMETER

RAW/FILTER TAPE FORMAT

DATA	DESCRIPTION	FORMAT
0.1	word count (8)	I
0.2	group count (128)	I
1	Greenwich time (seconds)	F
2	X-axis acceleration (raw) g's	F
3	Y-axis acceleration (raw) g's	F
4	Z-axis acceleration (raw) g's	F
5	X-axis acceleration (filtered) g's	F
6	Y-axis acceleration (filtered) g's	F
7	Z-axis acceleration (filtered) g's	F
8	temperature	F
9-1024	cyclic repetition of 1-8	F

ACCELEROMETER

MERGE/EPHEMERIS TAPE FORMAT

HEADER

Same as raw/filter tape

DATA	DESCRIPTION	FORMAT
0.1	word count (30)	I
0.2	group count (64)	I
1	Julian date of data (YYDDD)	F
2	calendar month	F
3	calendar day	F
4	Greenwich time (seconds)	F
5	altitude (Km)	F
6	latitude (+ 90)	F
7	longitude (+E)	F
8	geocentric velocity (Km/sec)	F
9	velocity relative to atmosphere (Km/sec)	F
10	local time (seconds)	F
11	revolution number	F
12	angle between geocentric and atmospheric velocities (degrees)	F
13	vacant	F
14	vacant	F
15	solar declination (degrees)	F
16	vacant	F
17	vacant	F
18	vacant	F
19	X-axis acceleration (raw)	F
20	Y-axis acceleration (raw)	F
21	Z-axis acceleration (raw)	F
22	X-axis acceleration (filtered)	F
23	Y-axis acceleration (filtered)	F
24	Z-axis acceleration (filtered)	F
25	temperature	F
26	vacant	F
27	vacant	F
28	X-direction clockwise from north (degrees)	F
29	magnetic local time (seconds)	F
30	vacant	F
31-1920	cyclic repetition of 1-30	F

ACCELEROMETER

MODEL/DENSITY TAPE FORMAT

HEADER

Same format as raw/filter tape, except model run date (MM/DD/YY) added in word 37 and ref. area M added in word 40

DATA	DESCRIPTION	FORMAT
0.1	word count (30)	I
0.2	group count (64)	I
1	X-axis wind speed (Km/sec)	F
2	Y-axis wind speed (Km/sec)	F
3	Z-axis wind speed (Km/sec)	F
4	Greenwich time (seconds)	F
5	altitude (Km)	F
6	latitude (+ 90)	F
7	longitude (+E)	F
8	geocentric velocity (Km/sec)	F
9	atmospheric velocity (Km/sec)	F
10	local time (sec)	F
11	revolution number	F
12	angle (in degrees) between (8) and (9)	F
13	CDX	F
14	CDY	F
15	normalized density (200 Km)	F
16	J71 model density	F
17	MSIS model density	F
18	measured density	F
19	X-axis acceleration (raw)	F
20	Y-axis acceleration (raw)	F
21	Z-axis acceleration (raw)	F
22	X-axis acceleration (filtered)	F
23	Y-axis acceleration (filtered)	F
24	Z-axis acceleration (filtered)	F
25	temperature	F
26	Kp (6-hour lag)	F
27	F (one day lag)	F
28	X-direction clockwise from north	F
29	magnetic local time (seconds)	F
30	CDZ	F
31-1920	cyclic repetition of 1-30	F

END
8-87
DTIC